PROPERTY OF
PRINCETON
THEOLOGICAL
SEMINARY.

AC 8 .D6 1848 v.10
Dick, Thomas, 1774-1857.
The complete works of Thomas
Dick

Digitized by the Internet Archive
in 2019 with funding from
Princeton Theological Seminary Library

https://archive.org/details/works10dick_0

UNIFORM EDITION.

THE

SOLAR SYSTEM:

WITH

MORAL AND RELIGIOUS REFLECTIONS

IN REFERENCE TO

The Wonders therein Displayed.

Thou Sun, of this great world both eye and soul,
Acknowledge Him thy greater, sound his praise
In thy eternal course, both when thou climb'st,
And when high noon hast gain'd, and when thou fall'st.
Moon, that now meet'st the orient sun, now fliest
With the fix'd stars, fix'd in their orb that flies;
And ye five other wandering fires, that move
In mystic dance, not without song, resound
His praise, who out of darkness call'd up light.

MILTON.

BY THOMAS DICK, LL.D.

AUTHOR OF "CELESTIAL SCENERY," "THE SIDEREAL HEAVENS," "THE PRACTICAL ASTRONOMER," ETC. ETC.

VOL. X.

PHILADELPHIA:
E. C. & J. BIDDLE, 6 SOUTH FIFTH ST.
STEREOTYPED BY L. JOHNSON AND CO.
1848.

Printed by T. K. & P. G. Collins.

PROPERTY OF
PRINCETON
THEOLOGICAL
SEMINARY

PREFACE.

THE following work is chiefly designed for juvenile readers, and for those who have hitherto acquired but a slender acquaintance with the general facts of astronomical science. With this view, the attention of the reader is, in the first place, directed to the general aspect and the apparent motions of the heavens, in order that he may be induced to contemplate with his own eyes the apparent movements of the celestial vault, in all its variety of aspects, as beheld in different countries and at different seasons of the year. Without such observations, the student of astronomy can never acquire a clear and accurate view of the economy of the solar system and the phenomena it presents; and therefore such personal observations are particularly recommended to all the lovers of astronomical science.

This work is a different one from "Celestial Scenery," though in some points there must necessarily be a certain coincidence. The statements of the distances, magnitudes, and general appearances of the planets must necessarily be the same in both; but the particular descriptions, remarks, and moral and religious reflections are different. A great variety of subjects likewise is introduced which are not noticed in "Celestial Scenery," such as the following:—the figure of the Earth —view of its surface, atmosphere, and the method of finding its dimensions—celestial phenomena arising from the annual motion of the earth—the *destination of the earth* and the final cause of its creation—motions

and aspects of the superior planets—general remarks on the solar system—method of acquiring an approximate idea of a million of units—the doctrine of *Eclipses*, with tables and descriptions of the most remarkable eclipses of the sun and moon—descriptions of the seasons of the year, and their characteristics in different countries—Reflections, moral and religious—history of astronomy—explanation of astronomical terms, &c. On these and various other topics a considerable variety of interesting facts and sketches will be found more or less illustrated.

One great object which the author has uniformly kept in view, has been to lead the minds of the young from the creature to the Creator, and to direct them to contemplate his attributes as displayed in the motions, magnitudes, and mechanism of the heavens, and to render their views of creation subservient to their moral and spiritual improvement, and to their preparation for a higher sphere of existence—an object which should always be kept in view in our contemplation of the works of God.

CONTENTS.

INTRODUCTION.

Object and Sublimity of Astronomy—Appearance of the Heavens to a common Observer—Objects of this Science lead to sublime and interesting Trains of Thought—Its Relation to Religion—The Scriptures direct our Attention to this Subject—It is our Duty to contemplate the Works of God—Plan of the following Work.....Page 11

CHAPTER I.

ON THE GENERAL ASPECT AND THE APPARENT MOTIONS OF THE HEAVENS.

Preliminary Remarks..... 15

SECT. I.—ON THE APPARENT MOTIONS OF THE HEAVENS DURING THE DAY.

Apparent Movements of the Sun, as seen at different Seasons, and as viewed from different Regions of the Globe—Sun's apparent annual Motion: how observed—How the Motions of the Sun appear in southern Latitudes and at the Poles—Stars above the Horizon during the Day, and may sometimes be seen while the Sun is shining..... 16

SECT. II.—ON THE APPARENT MOTION OF THE HEAVENS DURING THE NIGHT.

General Appearance of the starry Heavens—How their apparent Motions may be perceived—Aspects of the Stars in the southern and in the northern Regions of the Heavens—Positions of the Great Bear at different Seasons—Caution to be observed in making Observations—Position of the Pole and the Pole Star—Positions of certain Stars and Constellations in the beginning of January—Appearance of the Stars at the Equator and at the North Pole 21

SECT. III.—CONCLUSIONS DEDUCED FROM THE PRECEDING FACTS AND OBSERVATIONS.

Earth appears sustained between two Hemispheres of the Heavens—Rapid and astonishing Motions somewhere exist, either in the Earth or in the Heavens—Reflections on the Power of the Deity 28

CHAPTER II.

ON THE FIGURE AND MOTION OF THE EARTH.

SECT. I.—ON THE FIGURE OF THE EARTH, AND THE ARGUMENTS WHICH PROVE THAT IT IS NEARLY IN THE SHAPE OF A GLOBE.

Preliminary Remarks..... 30
Opinions formerly entertained on this Subject—Four Arguments, derived from different Sources, particularly illustrated—Argument taken

from an Eclipse of the Moon—Consequences which flow from the globular Figure of the Earth—It is the best adapted to a habitable World—Discovery of the true Figure of the Earth, an important Fact in the History of Providence..... Page 31

SECT. II.—ON THE MOTIONS OF THE EARTH.

Motion actually exists—Rate of Motion in the celestial Bodies, were the Earth at Rest—Rate of Motion, if the Earth move, illustrated by a Figure—Which of these Motions is most probable and correspondent to the Wisdom of the Almighty—A certain Rate of Motion would shatter the Universe to Atoms—No Instance of a larger Body revolving round a smaller—Arguments for the Earth's Motion derived from the Wisdom of the Deity..... 38

SECT. III.—REFLECTIONS SUGGESTED BY THE MOTIONS OF THE EARTH AND HEAVENS.

At what Rate we are carried through the Regions of Space during the Hours of Sleep, and from one Season of the Year to another—Rapid Motions of the Heavens—Original Cause of all Motion—Scene of Wonders which such Motions present—Practical Instructions deducible from this Subject..... 44

CHAPTER III.

DESCRIPTION OF THE SUN, OF THE INFERIOR PLANETS, AND OF THE EARTH AND MOON.

Introductory Remarks..... 48

SECT. I.—THE SUN.

Its general Appearance and Effects in the visible Creation—Its Magnitude illustrated, compared with other Magnitudes—Displays of the Glory of the Creator—Nature and physical Constitution of the Sun—Description of the solar Spots—Delineation of some of them—Bright solar Spots—Conclusions respecting the Constitution of the Sun—Beneficial Effects produced by this Luminary—Displays the Power and Beneficence of the Creator—An Emblem of the Sun of Righteousness..... 49

SECT. II.—THE PLANET MERCURY.

Arrangement of the Planets in the solar System—Amplitude of their Orbits—Orbits of Comets—Mercury, its Distance, Size, and the Velocity of its Motion—Its Motion and Phases—Quantity of Light on its Surface—Its Temperature—Orbit elliptical—Transits of—Is probably inhabited..... 59

SECT. III.—ON THE PLANET VENUS.

Its Distance, Magnitude, Motion, Rotation, etc.—Discoveries made on this Planet by the Telescope—Galileo and the Senators of Venice—Observations of Cassini—Schroeter's Observations and Discoveries—Mountains on Venus—Apparent Motions of this Planet—Its superior and inferior Conjunctions—Description and Delineation of its Phases—Periodical Revolution—Its Transits, etc.—Reflections on the Morning Star, as emblematical of intellectual Light and Joy..... 65

SECT. IV.—THE EARTH CONSIDERED AS A PLANETARY BODY.

(1.) *General View of the Earth's Surface, Atmosphere, Magnitude, and Method of finding its Dimensions.*

Earth a Body which reflects Light in common with the other Planets—Its Appearance from the Moon—Planets dark Bodies in themselves—General Aspect of the Earth's Surface—Magnitude of its Continents, Seas, and Oceans—Its *Atmosphere*, and the Properties with which it is invested—*Dimensions* of the Earth—How ascertained—Its *Circumference;* Mode of measuring it—Various Measurements of a Degree of the Meridian..... Page 72

(2.) *Proofs of the annual Motion of the Earth.*

General Considerations which render this motion highly probable—Demonstrative Arguments—Arguments derived from the Aberration of Light—Importance of acquiring correct Views on this Subject in Reference to our Conceptions of the Divinity..... 81

(3.) *Phenomena arising from the annual Motion of the Earth.*

The Sun will appear to move through the Circuit of the Heavens—Ecliptic explained—Apparent Motion of the Sun, as seen from other Planets—Why we behold different Clusters of Stars at different Seasons..... 85

(4.) *On the Destination of the Earth, or the final Cause of its Creation.*

Matter exists chiefly for the sake of sentient and intelligent Beings—The Creator's Design in the Formation of Man—Arrangements made for his Happiness—Restriction in God's Transaction with him—Fall of Man from his State of primitive Integrity—The Mercy of his Creator displayed—The promised Messiah, and Preparations for his Advent—Extraordinary Events which accompanied the Sacrifice he offered—Proclamation of Pardon and eternal Happiness to the Inhabitants of the World—Reasons why this Proclamation has been withheld from the Majority of the Nations—Prospect of the Regeneration of the World—Importance of studying the material Universe in Connection with intellectual Beings and moral Truths—Population of the Earth—Numbers passing daily into the invisible World—Population which the Earth is capable of sustaining—Numbers of other living Beings—Various other Facts respecting the Earth..... 88

SECT. V.—ON THE MOON.

Motions of the Moon—Illustrated by a Diagram—Phases and general Appearances of this Orb—Illustrations of its Phases—How the Earth appears as seen from the Moon—Proofs that the Earth shines upon the Moon—Appearance of its Continents and Seas—Moon presents only one Side to the Earth—Earth appears in a fixed Position as seen from the Moon—Moon's Distance, Diameter, and other Dimensions—*Telescopic Appearances* of the Moon—Its circular Plains—Peculiarity of its mountain Scenery—Its Depressions and Cavities—Its picturesque and sublime Scenery—Delineation of certain Portions of its Surface—Various astronomical Facts in relation to the Moon—Is probably inhabited—Its Beauty and Utility in relation to our Globe..... 95

CHAPTER IV.

DESCRIPTION OF THE SUPERIOR PLANETS OF THE SOLAR SYSTEM.

SECT. I.—ON THE MOTIONS AND ASPECTS OF THE SUPERIOR PLANETS.

Distinctions, in seven Particulars, of the superior and inferior Planets—Apparent Motion of the superior Planets as seen from the Earth.. 112

SECT. II.—ON THE PLANET MARS.

Remarks on its Name, and on the Atrocity of War—Its Distance—Period of Revolution—Position in 1845 and 1847—Its Spots and Rotation—Inclination of Axis—Magnitude—Telescopic Appearance—Atmosphere—Polar Spot—Land and Water—Conclusions respecting its Constitution..... Page 115

SECT. III.—ON THE NEW PLANETS.

Their Situation in the System—History of their Discovery—Their Magnitudes and Distances—Their Singularities and Anomalies—Supposed to be the Fragments of a larger Planet—Reflections suggested by the State in which these Planets now exist..... 120

SECT. IV.—ON THE PLANET JUPITER.

Its Distance—Revolution—Magnitude, compared with that of the Earth—Rotation—Rate of Motion—Inclination of Axis—Direct and Retrograde Motions, etc.—Present Position—Telescopic Appearance—Apparent Magnitude with different Powers—Its Belts, their Number and Appearance—Conjectures respecting their Nature—Improbability of their being produced by Winds, etc.—Different Representations of them—Figure of this Planet—Quantity of Light, its Mass, Density, etc..... 126

SECT. V.—ON THE SATELLITES OF JUPITER.

History of their Discovery—Form a System of revolving Bodies, analogous to the Solar System—Their Revolutions and Eclipses—Powers requisite for observing them—Table of their Magnitudes, Periods, etc.—Representation of their Orbits—Their Utility in finding the Longitude—Motion of Light—Sublime Phenomena they present to the Inhabitants of Jupiter—Reflections on the Sublimity and Motion of this Planet, and on the Omnipotence of the Deity..... 133

SECT. VI.—ON THE PLANET SATURN

Its Distance and Rotation—Its Motion and present Position—Telescopic Appearance—Its Magnitude—Belts—Figure—Quantity of Light—Its Satellites, and by whom discovered—Cassini's Telescopes—Herschel's—Powers requisite for observing these Satellites—Their Periods of Revolution—Sublime Phenomena they present in the Firmament of Saturn..... 138

SECT. VII.—ON THE RINGS OF SATURN.

History of their Discovery, and Conjectures formed respecting the Phenomenon—Dimensions of the Rings, according to Sir J. Herschel—Their Solidity, and Area—Their Appearance from the different Regions of the Planet—Four Representations of them—Their various Aspects as viewed through Telescopes at different Periods—Their occasional Disappearance—Some of the Uses or Designs for which they are intended—Supposed Division of the outer Ring—Reflections on their Grandeur, and the Power of God..... 143

SECT. VIII.—ON THE PLANET URANUS.

Former and present supposed Dimensions of the Solar System—Herschel's Telescopes and Discoveries—Discovered Uranus—Its Size and Distance—Rate of Motion—Quantity of Light and Heat—Its Satellites, their Period and Distance—Direction of their Motions..... 150

SECT. IX.—GENERAL REMARKS ON THE SOLAR SYSTEM.

Whether other Planets may exist within its Range—Order and Harmony which prevail in the System—Unity and mutual Relationship of the Bodies which compose it—Unity of the Supreme Being—Illustrations of the Distances and Magnitudes of the Planets—Summary View of the Solar System..... Page 154

Method of acquiring an approximate Idea of a Million of Units—Difficulty of forming an accurate Conception of such a Number—Various Illustrations—Method suggested by Mr. Martin of Chatham, illustrated by a Figure—Incomprehensible Nature of the Universe, as to Distances and Magnitudes, etc..... 159

CHAPTER V.

ON COMETS.

Meaning of the Term—How Comets are distinguished from Planets—Length of their Tails, and Opinions respecting them—Form of their Orbits—Account of some remarkable Comets—Comets of 1807 and 1811—Gambart's and Encke's Comets—Numbers of Comets—Opinions respecting them in former Ages—Whether they may come in Contact with the Earth—Destination of Comets..... 162

CHAPTER VI.

ON THE ECLIPSES OF THE SUN AND MOON.

Opinions respecting Eclipses in former Times—Nature of an Eclipse, and the different Kinds of them..... 168

SECT. I.—ON THE ECLIPSES OF THE MOON.

Cause of lunar Eclipses—In what Circumstances they happen—Figures representing the Nature of lunar Eclipses—Facts in relation to them—Their Duration, etc..... 169

SECT. II.—ON THE ECLIPSES OF THE SUN.

Nature of a solar Eclipse, and when it happens—Explanation of a Diagram illustrative of solar Eclipses—Various Facts in relation to solar Eclipses—Periods of Eclipses—Darkness which accompanied our Saviour's Crucifixion must have been Supernatural—Account of a total Eclipse of the Sun—Description of the Phenomena which accompanied the total Eclipse of 1724, as seen in England—Total Eclipses which will happen in future Years—Description of a total Eclipse of the Sun, at Vienna, in July, 1842—Table of solar Eclipses during the present Century—Utility of Eclipses..... 173

CHAPTER VII.

ON THE SEASONS, AND THE DIFFERENT LENGTHS OF DAYS AND NIGHTS.

Succession of Day and Night—Seasons in the frigid, temperate, and torrid Zones—Characteristics of the different Seasons—Description of Spring, of Summer, of Autumn, of Winter—Seasons produced by the Operation of simple Principles—Change of Seasons illustrated by a Diagram—General Remarks—Why our Weather is coldest when the Sun is nearest us—Such Seasons as we now enjoy are not the same as in the primeval State of Man—Various moral Reflections in relation to the Seasons..... 182

CHAPTER VIII.

REFLECTIONS, MORAL AND RELIGIOUS, IN REFERENCE TO THE SOLAR SYSTEM.

Astronomy presents to view Objects calculated to excite solemn Reflections, and to raise our Views to the Great Creator—1. The Solar System exhibits a striking Display of Almighty Power—This Power, thus displayed, lays a Foundation for the Hope and Comfort of the Christian—2. This System displays the Wisdom and Benevolence of the Creator—Various Instances of Wisdom and Goodness—3. The Facts it exhibits have a Tendency to moderate the Pride of Man, and to promote Humility—The wisest and most exalted Beings in the Universe are characterized by Humility—Scriptural Declarations respecting it—4. Astronomy affords a striking View of the Condescension of God—5. The Studies connected with Astronomy tend to prepare the renewed Spirit for the Employments of the future World—Moral and spiritual Dispositions requisite—The first Step to eternal Felicity—The Course to be prosecuted in order to be fitted for Heaven—The blessed Effects of prosecuting this Course 196

APPENDIX.

I. New Discoveries in the Planetary System 211

II. Brief Sketch of the History of Astronomy 220

III. Explanation of Astronomical Terms 226

IV. The Telescope 234

THE

SOLAR SYSTEM.

INTRODUCTION.

Of all the sciences which are the subject of human study and investigation, Astronomy must be admitted to be the most interesting and sublime. It teaches us the motions, the magnitudes and distances of the heavenly bodies—their diversified phenomena, the laws by which they are directed in their varied movements, and the grand designs they are intended to fulfil in the vast system of the universe.

The objects with which this science is conversant are so grand and marvellous—surpassing every thing that could have been imagined in the infancy of science—that they tend to enlarge the field of human contemplation, to expand to an indefinite extent the conceptions of the human intellect, and to arouse the attention and excite the admiration even of the most incurious and uncultivated minds. The vast magnitude of the heavenly bodies, so far surpassing what could be conceived by their appearance to the unassisted eye; their incalculable numbers; the immense velocity of their motions, and the astonishing forces with which they are impelled in their career through the heavens; the attractive influence they exert upon each other, at the distance of hundreds of millions of miles; and the important ends they are destined to accomplish in the universal empire of Jehovah; present to the human imagination a scene, and a subject of contemplation, on which the soul of man might expatiate with increasing wonder and delight, during an indefinite series of ages.

Even to a common observer, the heavens present a sublime and elevating spectacle. He beholds an immense concave hemisphere of unknown dimensions, surrounding the earth in every region, and resting as it were upon the circle of the horizon. From every quarter of this vast expanse—when

the shades of night have spread over the earth—he beholds numerous lights displayed, proceeding onward in solemn silence, varying their aspects at different seasons, moving with different degrees of velocity, shining with different degrees of splendour, and all calculated to inspire admiration and awe. Wherever he travels abroad, either on the surface of the land or of the ocean, this celestial vault still appears encompassing this lower world; and, after travelling thousands of miles, it appears still the same, and seems to make no nearer an approach than when the journey commenced. While contemplating this wonderful expanse with the eye of reason and imagination, the mind is naturally led into a boundless train of speculations and inquiries. Where do these mighty heavens begin, and where do they end? Can imagination fathom their depth, or human calculations, or figures, express their extent? Have the highest created beings ever winged their flight across the boundaries of the firmament? Can angels measure the dimensions of those heavens, or explore them throughout all their departments? Is there a boundary to creation beyond which the energies of Omnipotence are unknown, or does it extend throughout the infinity of space? Is the immense fabric of the universe yet completed, or is Almighty Power still operating throughout the boundless dimensions of space, and new creations still starting into existence?

Such views and inquiries have a tendency to lead the mind to sublime and interesting trains of thought and reflection, and to afford scope for the noblest energies and investigations of the human intellect. A serious contemplation of the heavens opens to the mental eye a glimpse of orbs of inconceivable magnitude and grandeur, and arranged in multitudes which no man can number, which have diffused their radiance on our world during hundreds of generations. It opens a vista which carries our views into the regions of infinity, and exhibits a sensible display of the immensity of space, and of the boundless operations of Omnipotence: it demonstrates the existence of an eternal and incomprehensible Divinity, who presides in all the grandeur of his attributes over an unlimited empire. Amidst the silence and the solitude of the midnight scene, it inspires the soul with a solemn awe, and with reverential emotions; it excites astonishment, admiration, and wonder, and has a tendency to enkindle the fire of devotion, and to raise the affections to that ineffable Being who presides in high authority over all the movements of the universe. It teaches us the littleness of man, the folly of

pride and ambition, and of all that earthly pomp and splendour with which mortals are so enamoured—and that our thoughts and affections ought to soar above all the sinful pursuits, and transitory enjoyments, of this sublunary scene.

Such being the views and the tendencies of this science, it ought to be considered as bearing an intimate relation to religion, and worthy the study of every enlightened Christian. It has been said, and justly, by a celebrated poet, that "An undevout astronomer is mad." The evidence of a self-existent and eternal Being, whose wisdom is inscrutable, and whose power is uncontrollable, is so palpably manifested in the arrangement and the motions of the celestial orbs, that it cannot but make an indelible impression on every rational and reflecting mind. Though the heavenly bodies have "no speech nor language," though they move round the earth in silent grandeur, and "their voice is not heard" in articulate sounds, yet "their line is gone throughout all the earth, and their words to the end of the world"—proclaiming to every attentive spectator, that "The hand that made them is Divine." So that there is scarcely a tribe, or nation, on the face of the earth so inattentive and barbarous as not to have deduced this conclusion from a survey of the movements of the celestial orbs. "Men," says Plato, "began to acknowledge a Deity, when they saw the stars maintain so great a harmony, and the days and nights throughout all the year, both in summer and winter, to observe their stated risings and settings." Another heathen philosopher, Cicero, thus expresses his sentiments on this point: "What can be so plain and clear as, when we behold the heavens, and view the celestial bodies, that we should conclude there is some Deity of a most excellent mind by whom these things are governed—a present and Almighty God. Which, he that doubts of, I do not understand why he should not as well doubt whether there be a sun that shines, and enlightens the world."

The sacred Scriptures, in numerous instances, direct our attention to this subject. "The heavens," says the psalmist, "declare the glory of God;" that is they manifest his wisdom and power, and beneficence to the inhabitants of the world; —"the firmament showeth forth," or publicly declareth, "his handiwork." "Day unto day uttereth speech, and night unto night showeth knowledge. There is no speech nor language where their voice is not heard." In reference to that department of creation which astronomy explores, it may be said with peculiar propriety, in the language of Scripture,

"The works of the Lord are great, sought out of all them that have pleasure therein." Throughout the volume of inspiration, our attention is frequently directed to the contemplation of the heavens: "Lift up thine eyes on high, and behold who hath created these things.—The everlasting God, the Lord, the Creator of the ends of the earth, who fainteth not, neither is weary; there is no searching of his understanding.—He bringeth out their host by number, and calleth them all by names: by the greatness of his might, for that he is strong in power; not one faileth.—It is he that sitteth upon the circle of the earth, and the inhabitants thereof are as grasshoppers.—All nations before him are as nothing; and they are counted to him less than nothing, and vanity."—"Hearken unto this, O Job: stand still, and consider the wondrous works of God."

Hence it appears, that it is not to be considered merely as a matter of taste, or as a rational amusement, but as an imperative duty, to contemplate the works of the Most High, and especially the manifestations of his power and Godhead which the heavens display—that we may derive more enlarged conceptions of his glorious attributes, and be enabled to render to him that tribute of adoration and praise which is due to his name. For it is represented as one of the characteristics of the ungodly that, while "the harp, and the viol, and the tabret, and pipe, and wine are in their feasts,—they regard not the work of the Lord, neither consider the operation of his hands;" and consequently "he will destroy them, and not build them up." It is therefore the incumbent duty of the young; of every professing Christian; and of every rational inquirer, not only to study the facts, doctrines, and duties exhibited in the system of Divine revelation, but also to contemplate the manifestations of the Creator as exhibited in the system of creation. They are both revelations of the same almighty and beneficent Being—emanations from the same adorable Divinity; and the views and instructions they respectively unfold, when studied with reverence and intelligence, are in perfect harmony with each other. The study of both combined, is calculated to make the man of God perfect, and "throughly furnished unto all good works."

In the following small volume, it shall be our endeavour to direct the general reader in the study of some of those objects which the heavens unfold; and we shall chiefly select those parts of astronomical science which are most level to the comprehension of those who have had little opportunity of engaging in scientific pursuits. In the present volume, it is

proposed to confine ourselves chiefly to a description of the Solar System, and the phenomena it exhibits, together with a few instructions as to the best mode of contemplating the apparent motions and the diversified aspects of the firmament. The discoveries which relate to the sidereal heavens—the general arrangement of the fixed stars, their distances and magnitudes—the facts which have been discovered respecting new stars—variable stars—double and triple stars—the milky way—the different orders of the nebulæ—and a variety of other topics connected with such objects, will form materials for another volume similar to the present.

In the mean time we may just remark, that all the wonders we behold, both in the heavens above, and in the earth below, demand our serious attention and devout contemplation. They are all the workmanship of that great and adorable Being in whom "we live and move;" who at first "spake, and it was done;" who gave the command, and the whole of this stately fabric of heaven and earth started into being. It is the same God who created the planets and the host of stars, and that conducts them in all their rapid motions; who is also "the God and Father of our Lord Jesus Christ," and "the Author of eternal salvation" to all who obey him. All these works display his infinite power, his unerring wisdom, and the riches of his beneficence; and demand from every beholder that tribute of praise, reverence, and adoration which is due to Him "who created all things, and for whose pleasure they are and were created."

CHAPTER I.

ON THE GENERAL ASPECT, AND THE APPARENT MOTIONS OF THE HEAVENS.

Previous to entering on the study of astronomical science, and the phenomena of the solar system, it is requisite that the young inquirer should be directed to contemplate the general aspect of the heavens, and the apparent motions of the different bodies which present themselves to view in the regions of the firmament. No one can enter with intelligence on the study of astronomy, or acquire an accurate idea of its elementary principles, and of the arrangement and motions of the planetary bodies, unless he has been led to observe, with his own eyes, the apparent and more obvious pheno-

mena and aspects of the celestial orbs, as they present themselves to the view of any common and attentive spectator. For although the real motions of the heavenly bodies are, in many instances, very different from their apparent movements, and although many of them appear to move while they are absolutely at rest, yet it is necessary that their apparent motions and appearances should be accurately inspected, in order that, in the progress of investigation, we may be enabled to determine what bodies are really in motion, and what only appear to be in motion, in consequence of the motions of other bodies. In order to direct the untutored observer on this point, the following observations are stated.

SECTION I.—ON THE APPARENT MOTIONS OF THE HEAVENS DURING THE DAY.

In the first place, let us consider the appearance of the heavens as seen in the daytime. Sometimes it happens for days, and even for weeks together, that the sky is overcast with an assemblage of sable clouds covering the whole face of the firmament. In which case no celestial orb makes its appearance ; but the light transmitted through the clouds and reflected from their under surfaces, indicates that some luminous orb, the fountain of light, is above our horizon, and far beyond the upper region of the clouds, though its form and splendour cannot be perceived. At other times the concave of the sky appears of an azure colour, where scarcely a speck of cloud is to be seen—like a boundless desert, where no celestial orb makes its appearance—as at the dawning of the morning, when the aurora makes its appearance in the east. This faint light gradually increases, rising higher and higher in its brightness, a prelude of something still more grand and refulgent. The clouds near the horizon are tinged with purple and vermilion, and the mountain tops are clothed with brightness. At length, the disk of the sun disengages itself from the horizon by degrees, till the whole of his orb appears to view, and ascends the heavens with majestic grandeur. The sun is the only object which, during the day, appears conspicuous to the naked eye ; for although the moon is frequently visible in the daytime, yet she then appears with no greater brilliancy than a small cloud of the same size, and is scarcely noticed by a common observer.

The apparent movements of the SUN appear very different at different seasons of the year, and in different regions of the globe. In describing these apparent motions, we shall sup-

pose ourselves, in the first instance, in the latitude of fifty-two degrees north, which is nearly the latitude of London and several other large towns in England. The sun's apparent motions in this latitude will be nearly the same as when he is viewed from Holland, Denmark. Scotland, Nova Scotia, Canada, and the northern states of America. Suppose we begin our observations in winter, about the 21st December, when the days in our northern hemisphere are shortest. In this case, turning our eyes to the south-east quarter of the sky, a little after eight o'clock in the morning, we shall see the sun rising nearly on the south-eastern point of the compass, and gradually ascending the celestial vault. In about four hours, he comes to the meridian, or due south, the highest point of his elevation at that season; after which he gradually descends towards the west, and sets in the south-western part of the heavens, about four in the afternoon, having described a comparatively small arc of a circle above the horizon. At this time, when he arrives at the meridian, or the highest point of his diurnal course, he is only about fourteen degrees above the horizon.* If, after this period, the point at which the sun rises be observed, it will be found a little to the northward, every day, from the point at which he rose before. On the 21st of March, the sun rises due east, about forty-five degrees to the north of the point at which he rose on the 21st of December. The time of his rising is exactly six in the morning; six hours afterwards, he passes the meridian, at an elevation of thirty-eight degrees; and sets due west, at six o'clock in the evening. At this time, the day and the night are of an equal length, namely, twelve hours each.

If, again, we view the rising sun on the 21st of June, we shall find that he rises near the north-east, forty-five degrees farther to the northward than on the 21st of March. At this period, the sun describes a large circuit around the heavens; rising fifteen minutes before four in the morning, and advancing to an elevation of more than sixty degrees at noonday; after which he declines towards the west, and sets near the north-west quarter of the heavens, about a quarter past

* The circumference of the heavens, as well as that of the earth, is divided by astronomers into three hundred and sixty parts called degrees: consequently, the distance from the horizon to the zenith, or the point directly above our heads, is ninety degrees, or the one-fourth of the circumference of a circle. When, therefore, the sun is said to be elevated above the horizon fourteen degrees, it means, that he has risen to an altitude little more than the one-sixth part of the distance from the horizon to the zenith. The apparent breadth of the sun or moon is a very little more than half a degree.

eight in the evening. The length of the day, at this time, is about sixteen and a half hours; and as his course during the night is not far below the horizon, there is no absolute darkness during the absence of the sun; and his course may be traced by observing the motion of the twilight, or the aurora, gradually proceeding to the northern point of the heavens, and from that point to the north-east, where the solar orb again emerges from the horizon. After this period, the sun begins, every succeeding day, to rise in points nearer the south, and to take less extensive circuits round the heavens, till the 23d of September, when he again rises on the eastern point of the horizon, and sets in the west, which is the time of the autumnal equinox, when day and night are equal. From this period the sun gradually verges to points of the horizon south of the east, at the time of his rising, and the days rapidly shorten, till he again arrives near the south-eastern quarter of the heavens, where he is seen to rise on the 21st of December. Such are some of the apparent motions of the sun, in our quarter of the globe, throughout the different seasons of the year; and every one who resides in the country has an opportunity, every clear day, of observing these diversified movements.

Besides the motions to which we have now adverted, there is another apparent motion of the sun, in a contrary direction, which is seldom noticed by a common observer. Every day the sun has an apparent motion from west to east, at the rate of nearly a degree each day; and in the course of a year, or 365 days, 5^h, 48^m, and 51^s, he makes a complete circuit around the heavens. This motion manifests itself chiefly by the appearance of the heavens during the night. If, in the morning, some time before sunrise, we view those stars which are near the point of the horizon where the sun rises, in a week or two, we shall find that the same stars are more elevated near the time of sun-rising than before, and farther distant from him, indicating that he is moving through the heavens towards the east, and leaving these stars as it were behind him. If, again, in the evening, we mark those stars which are a little above the point of the setting sun, we shall find that every evening they make a nearer approach to the place where the sun goes down; till, after a short period, they approach so near this luminary as to be overpowered with his rays, and can no longer be seen, still indicating that the sun is approaching towards the east.

Perhaps the best way of tracing this is to mark the different positions of the Pleiades, or seven stars, with respect

to the sun. About the middle of January, at eight o'clock in the evening, the seven stars are seen nearly on the meridian, which observation should be noted down for the purpose of being compared with future observations. On the 1st of March, at the same hour, these stars will be seen nearly halfway between the meridian and the western horizon, while all the other stars, at the same elevation, will be found to have made a similar progress. About the 15th of April, they will be seen, at the same hour, very near the north-western horizon; and every day after this, they will appear to make a nearer approach to that part of the heavens in which the sun appears, till, being overpowered by the splendour of his rays, they cease to be visible. From these and similar observations, it will be easily perceived that the sun has an apparent motion through the circle of the heavens, and that the revolution is completed in the course of a year. The circle which the sun thus describes is called the ECLIPTIC, and is divided into twelve signs, and three hundred and sixty degrees.

The apparent motions of the sun appear somewhat different, when viewed from different regions of the earth. Were we placed in countries under the equator, such as at Borneo, Sumatra, the Gallipago isles, Quito, and other parts of South America, the sun at noon would shine directly from the zenith, at the time of the equinoxes, at which time objects would have no shadows. At all other times, the sun will appear either in the northern or the southern quarter of the heavens. During the one-half of the year, he shines from the north, and the shadows of objects fall to the south: during the other half, he shines from the south, and the shadows of objects are projected to the north; a circumstance which can never occur in our country, or in any part of the temperate zones. At the equator, too, there is a perpetual equality of days and nights throughout the year; the twilight is shortest, and the darkness of night rapidly succeeds the setting of the sun.

Were we placed in southern latitudes—for example, at the Cape of Good Hope, New South Wales, or Buenos Ayres, in South America—instead of beholding the sun moving along the southern part of the heavens, from the left hand to the right, as in our country, we should see him directing his course along the northern part of the sky, from the right hand to the left. In other respects, his apparent motions would nearly resemble those already described, excepting that when the sun is highest at mid-day to us, he appears lowest to the

inhabitants of these countries; their winter happening at the time of our summer. Were we placed in Lapland, Greenland, or other countries within the polar circle, the sun, in winter, would be absent for weeks and even for months together; and in summer he would shine without intermission for a corresponding portion of time; appearing every day to make a complete circle round the heavens, but never descending below the horizon during the lapse of six weeks, or even three or four months. Could we suppose ourselves placed at the north pole, the motion of the sun would present a different aspect from any of those now described. On the 21st of March, we should see a portion of the sun's disk appear in the horizon, after a long night of six months. This portion of the sun would appear to move quite round the horizon every twenty-four hours; it would gradually rise higher and higher till the whole orb of the sun made its appearance. As the season advanced, the sun would appear to rise higher and higher, till, on the 21st of June, he attained the altitude of twenty-three and a half degrees above the horizon; after which, his altitude would gradually decline till the 23d of September, when he would again appear in the horizon. During the whole of this period of six months, there is perpetual day; the stars are never seen, and the sun appears to go quite round the heavens every twenty-four hours without setting, in circles nearly parallel with the horizon.

Such are some of the motions and aspects of the sun, as viewed at different seasons of the year, and from different parts of the earth. Let it be carefully remembered that these motions are not real, but only apparent. While presenting all these diversified aspects and movements to spectators placed in different positions, it can be proved that the sun is, notwithstanding, a quiescent body in the centre of the planetary system. By the rotation of the earth round its axis from west to east every twenty-four hours, and by its revolution round the sun every year, all the apparent motions we have hitherto described are produced, and completely accounted for, as we shall afterwards show, when we come to illustrate the evidences which prove that the earth on which we dwell is a moving body.

When we view the sun pursuing his course through the heavens in a clear and serene sky, we are apt to imagine that there are no other celestial bodies diffusing their rays above our horizon. This, however, is far from being the case. In the full blaze of day, there are as many stars, at an

average, around us in the firmament, as are beheld in a clear sky at the hour of midnight; but their light is overpowered by the more brilliant splendour of the sun. By means of equatorial telescopes, which can be made to point to any particular part of the heavens, all the larger stars of the firmament may be seen even at noonday, while the sun is shining in all his splendour; nay, there is scarcely a star visible to the naked eye, during night, but may be seen in this way during the blaze of day, and its exact position in the heavens pointed out. During a total eclipse of the sun, when the moon interposes her dark body between us and the sun, some of the planets and the larger stars have appeared as distinctly as at midnight; but the moment the moon has passed a little over the disk of the sun, and a glimpse of his beams has shone out, their feeble light becomes undistinguishable, and they are no longer perceived. Sometimes, too, it happens that stars have been seen from the bottom of deep wells and mines, when large ones happen to pass near the zenith during the day, and the planet Venus, when brightest, has frequently been seen with the naked eye, in the daytime, when at no great distance from the sun. Thus it appears that the sun passes through the heavens every day with stars all around him, although invisible to the unassisted eye—just as the moon, during night, is seen surrounded with stars, which the faintness of her light is not sufficient to overpower.* Hence it happens that astronomers can trace the exact path of the sun among the stars, every day, during his apparent annual circuit round the heavens. They can tell what stars are near and around the sun; what clusters he is leaving behind him, to what other clusters he is approaching; what stars or planets are near his margin, and what stars are behind his luminous globe, with as much accuracy as if they were all visible to the naked eye, as at midnight.

SECT. II.—ON THE APPARENT MOTIONS OF THE HEAVENS DURING NIGHT.

When a careless observer, on a clear evening, gazes upon the firmament, he beholds a number of shining points, some of them far more brilliant than others, dispersed throughout

* The author has frequently seen, by the equatorial telescope, in the daytime, not only numerous stars of the first, second, and third magnitudes, in regions of the firmament at a distance from the sun, but has perceived the planet Venus, when immersed in the sun's effulgence, and when it was within a degree of the margin of that luminary.

every region of the sky; but he cannot tell whether they appear to move or to remain in a fixed position; whether they shift their positions with respect to each other; whether they rise and set; whether all the stars visible at six o'clock in the evening are also seen at midnight, or whether the same clusters are to be seen in summer as in winter. There are thousands and millions of mankind who have occasionally gazed on the starry vault who could give no reply to such interrogations. Such is the apathy with which the most wonderful works of God are viewed by the great bulk of mankind; although only a few days or hours of serious observation would be sufficient to solve some of the questions to which we allude.

In order to illustrate the apparent motions of the heavens, let us suppose ourselves placed in a situation which commands an extensive view of the sky, about the beginning of January, at eight o'clock in the evening. At this period, on a serene evening, when the sky is destitute of clouds, a sublime and beautiful spectacle presents itself to view, as some of the most brilliant constellations are then above the horizon. We behold a vast hemisphere expanding over our heads, whose centre we seem to occupy, and which appears to rest upon our horizon. Above and around us, on every hand, a multitude of brilliant orbs, of various degrees of splendour, display their radiance. But whether they are in motion or at rest, does not appear at the first glance. We must make different observations, and wait for some time till their motion, or rest, be discovered. To ascertain this point, let us fix on a particular star, or a cluster of stars, and bring it in contact with a church spire, a chimney top, the twig of a tree, or any elevated object, and our line of vision, and in a short time we shall find it has moved onwards to the west, while we have remained stationary in our position. Or, if we direct a common telescope to any star, and fix the instrument in one position, in a few minutes the star will have passed from the field of view to the westward. If we look at a star near the horizon in the west, in a few minutes it will sink beyond the limits of our view, and disappear. If we mark any particular star just risen above the eastern horizon, in an hour or two it will be seen considerably elevated above its former position, and every minute rising higher and higher. If we look at any bright star rising due east, about six o'clock in the evening, at twelve, midnight, it will be on the meridian, or due south, at an elevation of thirty-eight degrees, and at six o'clock next morning, it will be seen setting at the western point of the horizon. In like manner, any other star

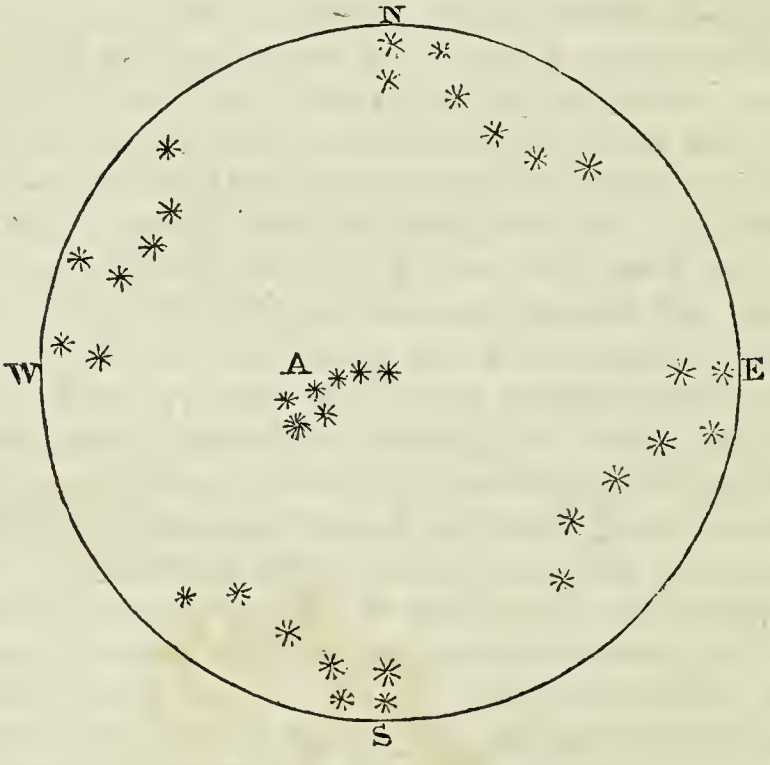
rising towards the east, north-east, or south-east, if carefully observed, will be found to rise gradually till it come to the meridian, and then decline in a western direction, till it set either in the west, north-west, or south-west. If it rise in the north-east, it will set in the north-west, and if it rise in the south-east, it will set in the south-west; in the former case describing a larger, and in the latter a lesser portion of a circle, in the sphere of the heavens.

The following are some varieties which may be observed in the apparent motions of the stars. If you look towards the south, you will observe some stars just appearing above the horizon, grazing this circle, as it were, but not rising above it, and then vanishing. If you observe a group a little to the east of the south, you will find them rising above the horizon, making a small arch, and then going down a little to the west of the meridian. If you mark another group rising much farther to the east, you will find these describing a much larger arch, and taking a much longer time before they go down to the westward of the meridian. If now you turn your face to the northern part of the sky, you will find some stars that just skim the horizon, at certain times, near the north point, and then gradually mount up to the top of heaven, till they come nearly over head, and then descend, and again nearly touch the northern horizon, and ascend again without ever disappearing, describing a complete circle above the horizon. Such are the bright stars Vega, Capella, and several others. Other stars that are higher than these, when seen near the northern horizon, likewise describe complete circles in the sky, without approaching the horizon; and these circles gradually diminish, till at last you arrive at a star which seems scarcely to move from the point where it is stationed—all the rest seeming to circulate around it as a centre. This is called the Pole Star, which, to a common observer, never seems to vary its position; and, in the latitude we have supposed, is elevated more than fifty degrees above the northern horizon. The time occupied by the stars now alluded to, in completing their circles, is about twenty-four hours, or, more accurately, is twenty-three hours, fifty-six minutes, and four seconds, and they all finish their revolutions in exactly the same period of time.

For the illustration of what has been now stated, let us suppose ourselves to be viewing the northern quarter of the heavens, about the beginning of November, at eight o'clock in the evening. At this time, the Great Bear, or *Ursa Major*, will appear near the lowest part of its course, not far from

the northern part of the horizon. I refer to this constellation, because it is generally known, even to common observers, and is sometimes distinguished by the names of "the Plough," and of "Charles's Wain." That part of the constellation which is generally recognised, consists of seven bright stars, of which the four towards the right form a kind of irregular square, and the three stars stretching out from it to the left form a kind of irregular curve. In the following figure, (fig. 1,) this constellation is represented in four positions

Figure 1.



Immediately above the letter S, in the lower part of the figure, are two stars, forming the right side of the square, the uppermost of which is called Dubbe, and the lower one Merak. They are about five degrees distant from each other, and are most frequently known by the name of "the Pointers," because they always point towards the pole star. The pole star is represented in the central part of the figure; it is about twenty-nine degrees—or nearly six times the distance of the two pointers—from Dubbe, and in whatever position this constellation may happen to be, these two stars always point to the pole star, which is the first bright star in a line with the pointers, at the proportional distance exhibited in the engraving; and by attending to this circumstance, the pole star may at all times be distinguished. Such is the position of this constellation at eight o'clock in the evening of the 1st of November. If now we view this constellation, about eleven o'clock the same evening, or a few evenings afterwards, we

shall find that it has moved considerably towards the east, and to a higher elevation; and at two o'clock the next morning, it will be seen in the position represented at E, with the pointers still directed to the pole star. At eight o'clock in the morning, it will be seen at N, when it will appear in the zenith, with the pointers pointing downward towards the pole. At two o'clock in the afternoon, if it could then be seen, it will appear as represented at W, to the west of the pole, and the pointers pointing eastward to the polar star; and again, about eight in the evening it will return nearly to its former position at S.

Again, this constellation appears in different positions, at the same hour, at different seasons of the year. We have seen that, in the beginning of November, at eight o'clock in the evening, it appears as represented at S; in the beginning of February, at the same hour, it will appear as represented at E; in the beginning of May, as exhibited at N; and in the beginning of August, at the same hour, as represented at W.

In order that none of my readers may fall into any mistakes, from what has been now stated, I may be permitted to mention the following anecdote:—A few years ago, I pointed out in the heavens, to a lady of my acquaintance, the constellation of the Great Bear, and showed her how she might mark its positions at different times, and its apparent revolution round the pole star. About a year afterwards, she told me she had carefully made the observations to which I had directed her, and found them to correspond to what I had stated. She appeared, however, to have paid no attention to any other stars, but those of the Great Bear; and on putting several questions to her on the subject, I found that she conceived of the motion of the Great Bear as if it had been a huge monster pursuing its way through the midst of the surrounding stars, as if they had all been at rest, without apparently shifting their position—somewhat like a huge animal pursuing its way through a crowd, whilst every individual of the crowd remained nearly in the same position. Now, that my readers may not fall into the same mistake, let it be carefully remembered that all the stars in the neighbourhood of the pole have the same apparent motions and revolutions as the Great Bear, all moving in concert, but some of them describing larger, and others smaller circles, around the polar point, and all completing their revolution in the same time, namely, in twenty-four hours.

Having represented the pole star in the centre of the en-

graving, to prevent mistakes, it may be proper to mention, that this star, although, to a common observer, it appears in a fixed position, is not exactly in the polar point: it is at present one degree and thirty-two minutes from the north pole of the heavens, and revolves around it every day in a circle of about three degrees in diameter. This motion may be perceived by placing a telescope in a fixed position, and directing it to this star, when we shall find that, after an hour or two, it will have moved out of the field of view. There is no star exactly at the polar point, and this is called the polar star, because it is the nearest bright star to the north pole of the heavens. It forms the tip of the tail, or the extremity, of *Ursa Minor*, or the Lesser Bear, which likewise consists of seven stars, arranged very nearly in the shape of the Greater Bear, but in a reverse order. This constellation, which is much nearer the pole than *Ursa Major*, may be seen revolving around it, in the same manner as we have described above, but the stars of which it is composed are much smaller, and not so easily distinguished as those of *Ursa Major*. When the Great Bear is at its lowest position, as at S, (fig. 1,) the square of the Lesser Bear is considerably to the westward, and the four stars, of which it is composed, are directly above the tail of the Great Bear, at the distance of about twenty degrees, as at A.

Let us now suppose ourselves contemplating the southern, eastern, and western parts of the heavens, about the beginning of January, at nine o'clock in the evening. At this time we shall see the seven stars, a very little to the west of the meridian, and at a very high elevation. Next to this cluster, on the east, but a little lower, is *Aldebaran*, or the Bull's Eye, a ruddy star of the first magnitude, in the constellation of Taurus. South by east of Aldebaran, and considerably below it, is the splendid constellation of Orion, distinguished by four bright stars forming an irregular square, or parallelogram, in the middle of which are three bright stars in a straight line, at equal distances from each other. This is one of the most splendid constellations in the heavens, and is distinguished by almost every common observer by the three stars now mentioned, which form the belt of Orion, or what Job calls "the bands of Orion," and are sometimes known by the names of "the three Kings," "the Yard," and "the Lady's Elwand." South-east from Orion, at a low elevation, is the star Sirius, belonging to *Canis Major*, or the Great Dog, which is considered the most brilliant fixed star in the heavens. North-east from Sirius, at a higher eleva-

tion, is Procyon, a bright star in *Canis Minor* or the Little Dog. North from Procyon, at a much higher altitude, are the bright stars Castor and Pollux, belonging to the constellation Gemini. If, then, three hours after having made these observations, or about midnight, we view the face of the heavens, we shall find a considerable alteration in the positions of the stars and constellations to which we have referred. The seven stars will then be found to have moved halfway between the meridian and the western horizon, followed by Aldebaran, which is then a considerable distance past the meridian to the westward. The constellation Orion is likewise westward of the meridian, and the bright star Sirius, which was formerly in the south-east, is now nearly due south. Procyon, and Castor and Pollux, which, at nine o'clock, were a great way towards the east, are, at midnight, not far from the meridian, and at a much higher elevation. All which circumstances show that the various clusters of stars, in the eastern, southern, and western portions of the heavens, have a regular and uniform apparent motion from east to west.

Such are some of the general appearances of the heavens, as viewed in our northern latitude; but, in several other quarters of the globe, their aspects will appear somewhat different. Were we placed under the equator, in the island of Sumatra, or about Quito, in South America, we should behold all the stars in the firmament proceeding in their courses from east to west. All the stars would appear to rise and set, and none of them would describe circles above the horizon, as some of them appear to do in our northern region. The north pole, which, in our latitude, is at a high elevation, would appear in the northern point of the horizon, and the south pole would, at the same time, be visible in the opposite quarter of the heavens. In our latitude, we cannot perceive above two-thirds of the stars which may be seen in the firmament, but, at the equator, all the visible stars of heaven may be perceived. During the space of twenty-four hours they all pass along above the horizon. The one-half of them, indeed, cannot be seen on account of the light of day, but, in the course of a year, they are all visible. Were we placed in Van Diemen's Land, or at the Cape of Good Hope, we should behold multitudes of stars which are never visible in our latitude, and the constellations of the Great and Little Bears, Cassiopeia, and other clusters, would be no longer visible. Could we take our station at the north pole of the earth, the stars would appear neither to rise or set, nor yet

to stand still. All the stars visible from this point would appear to move round the heavens above the horizon, in parallel circles, every twenty-four hours; and all that could ever be seen in such a situation might be perceived every hour and minute, in a clear sky, when the sun is absent. But, from this point, only one-half of the firmament is visible, and none of the stars belonging to the other half ever rise above the horizon.

SEC. III.—CONCLUSIONS DEDUCED FROM THE PRECEDING FACTS AND OBSERVATIONS.

An intelligent spectator, after having observed the various aspects of the heavens above described, will naturally inquire—Whence come those stars which are seen gradually emerging from the eastern horizon? Whither have those stars gone which have sunk beneath the western horizon? And what becomes of those stars during the light of day, which shine with so much splendour during the shades of night? A little reflection on the subject will soon suggest, that the stars which are seen rising above the eastern horizon, come from another hemisphere of the heavens, which is invisible from the point on which we stand, and which we are apt to imagine is below the hemisphere which we behold above us; and when they set in the west, return to that hemisphere again; and that the reason why the stars are not visible during the day, is because their light is overpowered by the more vivid splendour of the sun. We are also naturally led to conclude, from such appearances, that the world in which we dwell is suspended in empty space, and is surrounded on all sides, above and below, by the expanse of the firmament, in which the sun, moon, planets, and stars appear to perform their diversified motions and revolutions. Another conclusion which may be deduced from the preceding observations, is, that the whole sphere of the heavens performs an apparent revolution round our world; carrying, as it were, all the stars along with it in the space of twenty-four hours. Whether this motion be real, or only apparent, requires to be determined by certain rational considerations, and from the harmony and order which appear to be characteristic of the works of the Creator: to which subject we shall particularly direct our attention in the following chapter.

In the mean time, we may remark, that such general views of the motions of the starry firmament as we have already taken, have a tendency to expand the intellectual faculties, and to elevate the mind to the contemplation of some Great

Invisible Power, by which such mighty movements are conducted. When we behold the vast concave of the sky, with all its radiant orbs, moving in majestic grandeur around our globe, an idea of sublimity and almighty energy irresistibly forces itself upon the mind, which throws completely into the shade the mightiest efforts of human power,—so that the most stupendous machines ever constructed by human art can afford no assistance in forming a conception of that incomprehensible Power, which sustains and carries forward in their course thousands of spacious worlds. The shining orbs which the firmament displays are evidently placed at an immense distance from the earth, and consequently are bodies of an immense size; and if the apparent motions to which we have adverted were real, the swiftness with which they would fly through the regions of space would exceed all human calculation and conception. But whether these motions be real or apparent, we find motions actually existing among the orbs of heaven which astonish and overpower every rational and contemplative mind. The very circumstance, that motions so sublime appear in the expanse of the firmament, is a demonstrative proof that motions of a wonderful and incomprehensible nature exist somewhere; and the ideas of majesty, of grandeur, and of omnipotent energy, which this single circumstance is calculated to inspire, are such as irresistibly to lead the mind to the contemplation of a Being whose perfections are incomprehensible, and whose "ways are past finding out."

It does not require a scientific knowledge of astronomy in order that the mind may be impressed with sentiments of admiration at the movements which appear throughout the universe. For the works of God, when contemplated in any point of view, or on any theory, or hypothesis we may form, appear, like himself, wonderful, magnificent, and incomprehensible. The motions to which we have chiefly alluded, are either in the earth or in the heavens. If these motions really exist in the heavens, the mind is overpowered with astonishment at the idea of thousands and tens of thousands of vast globes of light, at immense distances, every day revolving around us with amazing velocity. If the motion chiefly exist in the earth, then we are still overwhelmed with wonder at the idea of a globe containing two hundred millions of square miles, with its mighty continents and oceans, and its numerous population, whirling around its axis every day, at the rate of a thousand miles an hour, and, in its course round the sun, flying with a velocity of eleven hundred and thirty

miles every minute! There is no alternative but that of admitting either the one or the other of these motions; and whatever view we take of this subject, or in whatever light we contemplate the phenomena of the heavens, we are almost irresistibly led to exclaim, "Great and marvellous are thy works, Lord God Almighty!" "Who can utter the mighty operations of Jehovah!" "The Lord God omnipotent reigneth!" The idea of a Being who thus incessantly displays such amazing energies demands from all his intelligent offspring a tribute of reverence and adoration, of gratitude and praise.

CHAPTER II.

ON THE FIGURE AND MOTION OF THE EARTH.

SEC. I.—ON THE FIGURE OF THE EARTH, AND THE ARGUMENTS WHICH PROVE THAT IT IS NEARLY IN THE SHAPE OF A GLOBE.

In the preceding chapter, we have given a description of the principal motions which appear in the heavens, both by day and by night. Every one, however illiterate, who has a desire to study "the wonderful works of God," has an opportunity, if he please, to observe most of the motions and phenomena to which we have adverted, provided he live in the country, or in a spacious street or square. Those who live in the narrow and dirty lanes and courts of London, Liverpool, Manchester, and other populous cities and towns, have no scope for making such observations, unless they occasionally retire to the open fields; and hence it is that the inhabitants of such places seldom know any thing of the general aspects either of the earth or of the heavens. It is, however, the incumbent duty of every man, and particularly of every Christian, to contemplate, with an eye of intelligence and devotion, the operations of the Most High, in order that he may be enabled to "praise Him for his mighty acts," and "according to his excellent greatness." And the man who will not give himself the trouble of occasionally devoting an hour or two to such studies and observations, virtually declares that the works of his Creator are unworthy of his contemplation; and consequently, that he deserves to remain in ignorance of the most sublime objects of creation, and of the most glorious manifestations of the Divinity.

Before proceeding to a particular description of the planetary system, it is requisite that we should acquire clear and definite views of the figure and motions of this earth, on which we reside; without which the general frame of the universe, and the order and arrangement of the solar system, cannot be appreciated or understood.

For a long period, during the dark ages, and the infancy of science, the world in which we dwell was considered as the largest body in the universe. It was supposed to be an immense plain, diversified with a few inequalities, caused by the mountains and vales; and that it stretched out in every direction to an unlimited extent, and was bounded on all sides by the sky. What was below this immense mass of land and water, and how it was supported, none could tell; though some of the Christian fathers strenuously asserted that the earth was extended infinitely downwards, and established upon several foundations. Such were the absurd and foolish opinions of those who viewed the system of nature through a false medium, and who were ignorant of the facts and principles of modern science. It is only within the period of the last three hundred years that the true figure and dimensions of the earth have been accurately ascertained. This figure is now found to be that of an oblate spheroid, very nearly approaching to the shape of a globe, or sphere. That this is in reality the form of our world will appear from the following considerations.

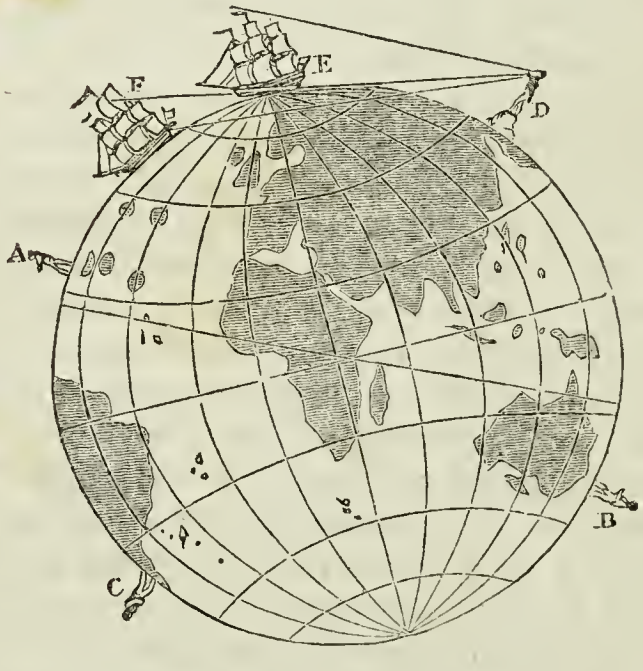
1. When, on a calm day, we take our station on the seashore, we shall perceive that the surface of the water is not quite plane, but a little convex, or rounded; and if we happen to be on one side of an arm of the sea, two or three miles broad, if we place our eyes near the water, and look towards the opposite coast, we shall plainly see the water elevated between our eyes and the opposite coast, so as to prevent our seeing the objects which are near the edge of the water. If we make the same experiment on a lake of two or three miles in extent, a small boat near the end of the lake may be seen by a man who is at some height above the water; but if we lay our eye near the surface, the view of the boat will be intercepted by the convexity of the water, which shows that the lake is a small segment of a globe.

2. When we view a ship taking its departure from the coast in any direction, as it retires from our view we may perceive the masts and rigging of the vessel when the hull has disappeared, and has sunk, as it were, beyond the boundary of our sight. First we lose sight of the hull, then of the

sails, and, last of all, of the topmast. On the other hand, when a ship is approaching the shore, the first part of it which is visible, when at a considerable distance, is the topmast; as it approaches nearer, the sails begin to be seen; and last of all the hull gradually comes within the limits of our sight—but the vessel will pass over several miles of the sea, from the time of our first perceiving the topmast till the hull appears. In order to make such observations with accuracy, it is requisite that a telescope should be used. What is it, then, that prevents the hull of a ship from being perceived when its topmasts are visible? It is evidently the round, or convex surface of the water rising up, as it were, or interposing between our eye and the lower part of the ship, when it has receded a certain distance. Now, as such appearances are observed on every sea and ocean on the face of the earth, it follows that the ocean at large is a convex surface, or a portion of a globe; and if the ocean be globular, so also is the land—notwithstanding that the hills and mountains form a few inequalities on its surface—for the portions of the land are all nearly on a level with the ocean, with the exception of the ranges of elevated mountains.

What has been now stated may be illustrated by the following figure, (fig. 2,) in which the convex surface of the

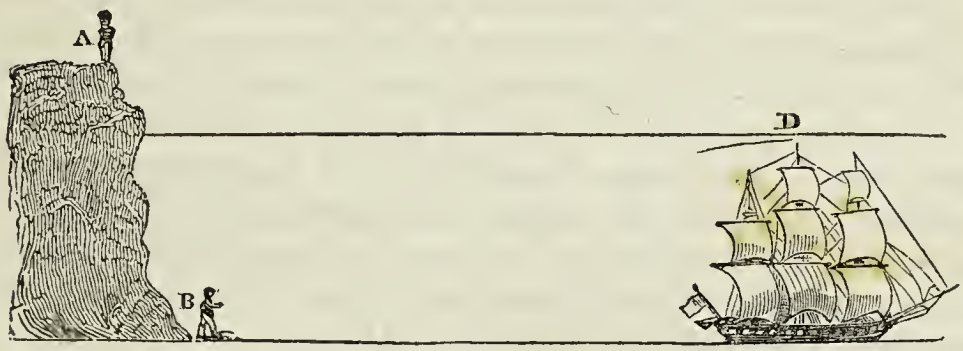
Figure 2.



globe is represented. At D a person is represented as standing on the top of a tower; and from that elevation he is enabled to see both the topmast and the hull of the ship E; which is evident, because right lines can be drawn without interruption from the eye, both to the topmast and to the hull.

Whereas a line drawn from the eye to the hull of the ship F, which is at a greater distance, is intercepted by the convex surface of the water interposing, and consequently the hull is invisible; but a line drawn from the eye to the higher parts of the vessel shows that the topmasts are visible, because light, when passing through the same medium, flows in straight lines from every object. In conformity with what has been now stated, we find that the higher the eye is placed, the farther will the view be extended. From a lofty mountain we obtain a much more distant and extensive prospect than from the plain below; and hence it is common for sailors to ascend to the top of the ship's mast, when they wish to descry objects at the greatest distance; as from such an elevation they can discover land, or other ships, at a greater distance than when they stand on deck. On the other hand, were the surface of the sea a level plain, as represented in fig. 3, the appearances would be very different. A line might be

Figure 3.



drawn from any object situate upon it, as the ship D, to the eye, whether it were placed high or low, at A or at B. In this case, any object upon the earth or sea would be visible at any distance which was not so great as to make the appearance of it too faint or small to be perceived. An object would be visible at the same distance whether the eye were high or low. The largest, and not the highest, objects would be visible at the greatest distance. The topmast of a ship would first disappear, and the hull, as being the largest body, would be longest visible; but this is contrary to all experience. The considerations now adduced are, therefore, clear and decisive proofs that the earth is not an extended plain, but a globular body; and it is astonishing that such a conclusion was not generally drawn till a few centuries before the present age.

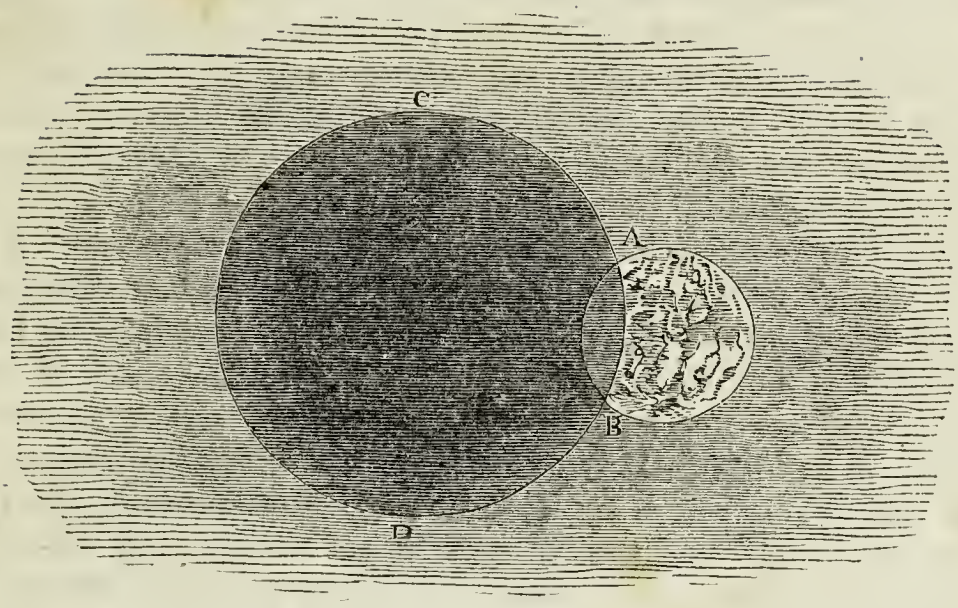
3. That the earth is round from east to west, appears from actual experiment; for many navigators, by sailing in a westerly direction, have gone quite round it from east to west.

They have set sail from England, crossed the Atlantic, rounded Cape Horn, sailed along the Great Pacific ocean to the northern coasts of New Holland, crossed the Indian sea, and passing the Cape of Good Hope, have again arrived, by traversing the Atlantic, to the port whence they set out. This experiment therefore shows that the earth is round from east to west; but it does not prove that it is also round from north to south; for it has never been actually circumnavigated in that direction, on account of the obstruction caused to navigation by the immense masses of ice within the polar regions. Had we therefore no other proof of the earth's rotundity than this, we might be apt to suppose it somewhat resembling the shape of a cylinder. But that the earth is in reality round from north to south, appears from the following circumstances. When we travel a considerable distance from north to south, or from south to north, a number of new stars successively appear in the heavens in the quarter to which we are advancing, and many of those in the opposite quarter gradually disappear. For example, in sailing toward the south, when we approach the equator the brilliant constellation called the Cross makes its appearance, which is always invisible in this country; and if we go still farther south, the constellations of the Great Bear, Cassiopeia, and other stars visible in our northern sky, will entirely disappear; which could not happen if the earth were a plane in that direction; for, in this case, all the stars of heaven would be visible in every point from the north pole to the south.

4. Another corroborative proof of the earth's globular figure is this: in cutting for a canal, in order to have the water on a level, certain allowances require to be made for the earth's rotundity. The slope requisite to be made on this account is about eight inches in the mile, thirty-two inches in two miles, and so on, increasing as the square of the distance. If the earth were a plane, no allowances of this kind would be requisite, in order that the water in a long canal might stand on a level.

5. The phenomena exhibited in eclipses of the moon present to the eye a clear demonstration that the earth is of a spherical form. It is well known that an eclipse of the moon is produced by the intervention of the body of the earth between the sun and the moon, which can only happen at the time of full moon, in which case, the shadow of the earth falls upon the moon. This shadow is found in all cases, and in every position of the earth and moon, to be of a circular figure, or the segment of a circle, as the whole shadow can-

Figure 4.



not be seen at one time. Thus, let A B (fig. 4) represent the moon while an eclipse is going on, and C D the shadow of the earth, which is much larger than the diameter of the moon. In every stage of the progress of an eclipse, the curve A B of the earth's shadow is distinctly perceived passing along the disk of the moon. But the entire shadow of the earth is not seen, because there is no bright object on which the whole of it can fall; only that part of it which covers the moon being visible. But since this shadow always appears a portion of a circle, it proves, incontestably, that the whole mass of land and water, of which the earth is composed, is nearly of a globular form.

If, therefore, we admit that the earth is of a globular form, it necessarily follows that it may be inhabited on all sides, and consequently, that those who live on the opposite side of the globe must have their feet pointing towards our feet, and their heads pointing in an opposite direction. Thus, in fig. 2, the person standing at A has his feet pointing to the feet of the one standing at B, and their heads pointing to regions of space directly opposite; and therefore if, by any motive power, they were to be carried forward in the direction to which their heads point, and the power to be continued, they would never meet through all eternity. The same may be said in reference to the persons supposed to be placed at C and D. It also follows, that, could we suppose a hole bored through the centre of the earth, commencing at the point where we now stand, and extending to the opposite side, it would terminate at our *antipodes*, and would measure nearly eight thousand miles. It likewise follows that this globe of land and water is either suspended in empty space, or is moving round its axis every day, or flying with immense

velocity round the sun every year. Whichever of these suppositions we hold to be true, a wonderful and sublime idea is conveyed to the mind. If we suppose the earth at rest in empty space, we have presented to view a globe—containing 264 millions of cubical miles, and weighing, at least, 2,200,000,000,000,000,000,000, or more than two thousand trillions of tons—resting upon nothing—suspended in the midst of infinite space, and surrounded by the immense bodies of the universe, with no material support but the invisible arm of Omnipotence, poising its immense mass of continents and oceans, and preventing it from sinking into the depths of infinity. If we suppose it to be turning round its axis, and revolving, at the same time, round the sun, then we have presented to view a still more astonishing idea—a globe, of the huge dimensions now stated, with its numerous population, flying through the spaces of immensity, without intermitting its speed a single moment, at the rate of sixty-eight thousand miles every hour. So that there is no view we can take of the works of the Almighty, in which we are not irresistibly excited to wonder and admire.

We may here also remark, that the globular figure of the earth is evidently the best adapted to a habitable world. It is the most capacious of all forms, and contains the greatest quantity of area in the least possible space. It is the best adapted to motion, both annual and diurnal, every part of the surface being nearly at the same distance from the centre of gravity and motion. Without this figure, there could have been no comfortable and regular alternation of day and night in our world, as we now enjoy ; and the light of the sun and the mass of waters could not have been equally distributed. Had the earth been of the figure of a cube, or pentagon, or of any other angular form, some parts would have been comparatively near the centre of gravity, and others hundreds or thousands of miles further from it. Certain countries would have been exposed to furious tempests, which would have overturned and destroyed every object; while others would have been stifled for want of currents and agitation of the air. One part would have been overwhelmed with water, and another entirely destitute of the liquid element; one part might have enjoyed the benign influence of the sun, while another might have been within the shadow of elevations a hundred miles high, and in regions of insufferable cold. In short, while one country might have resembled a paradise, others would have been transformed into a chaos, where nothing was to be seen but barrenness and desolation.

But the globular figure which the Creator has given to our world prevents all such inconveniences and evils, and secures to us all the advantages we enjoy from the equable distribution of light and gravity—of the waters of our seas and rivers, and of the winds and motions of the atmosphere. Hence it is that all the bodies of the planetary system are either spherical, or spheroidal bodies; nay, all the great bodies in the universe, so far as our knowledge extends, are found to be of a globular figure; and in this arrangement the wisdom and intelligence of the Almighty Creator are clearly to be perceived.

In short, the discovery of the globular figure of the earth constitutes an important fact in the history of Divine Providence, without which some of the grand designs of the Creator, in reference to our world, would not have been accomplished. It was in consequence of a knowledge of this fact that the continent of America was discovered, and the blessings of civilization, science, and Christianity conveyed to that region of the earth. On a knowledge of the true figure of the earth the art of navigation depends: and in consequence of this, the greater part of the world has been explored, and the way prepared for carrying the tidings of salvation to men of all nations, through faith in the crucified Redeemer. On the knowledge of the true figure of the earth depends our knowledge of its magnitude and dimensions; and on our knowledge of its magnitude, depends our knowledge of the distances of the sun and moon; and on our knowledge of the distance of the sun depends our knowledge of the respective distances of the planets, and the extent of the solar system; and on our knowledge of the extent of this system, depend our conceptions of the distances of the fixed stars, and of the vast magnitude and extent of the material creation; and on our views of the immensity of the universe, depend the enlarged conceptions we are now enabled to form of the attributes of that Almighty Being from whom we derived our existence, and whose "kingdom ruleth over all." Had the first link of this chain—our knowledge of the figure of the earth—been wanting, we should have remained in ignorance of all the important consequences, now stated, which have resulted from this discovery—so intimately connected are all the branches of useful knowledge, both human and Divine.

Had mankind always remained ignorant of this important fact, the circumnavigation of the globe would never have been attempted; vast portions of the habitable world would have remained unknown and unexplored; the intercourses which

now subsist among the various tribes and nations of mankind could not have been carried on; the tribes of the greater portion of the heathen world, and the countries in which they reside, would have been unknown; no extensive missionary enterprises could have been carried forward; the knowledge of "the salvation of God" could not have been communicated to all the nations that dwell upon the face of the earth, according to the predictions of ancient prophecy; and our ideas of the majesty and grandeur of the great Creator and Redeemer of men would have remained as low and contracted as in the dark ages, when it was considered, even by ecclesiastics, as a heresy and a crime to maintain that the earth is round like a globe, or ball, and that it may be inhabited on all sides. But now, in consequence of the knowledge we have acquired on this subject, the way is prepared for the accomplishment of the Divine purposes and predictions in relation to our race; our knowledge of creation, and the perfections of its Author, is extended; the path to future improvement and discovery is laid open; and every thing now appears, notwithstanding many obstacles, to be hastening onward to a glorious consummation.

SEC. II.—ON THE MOTIONS OF THE EARTH.

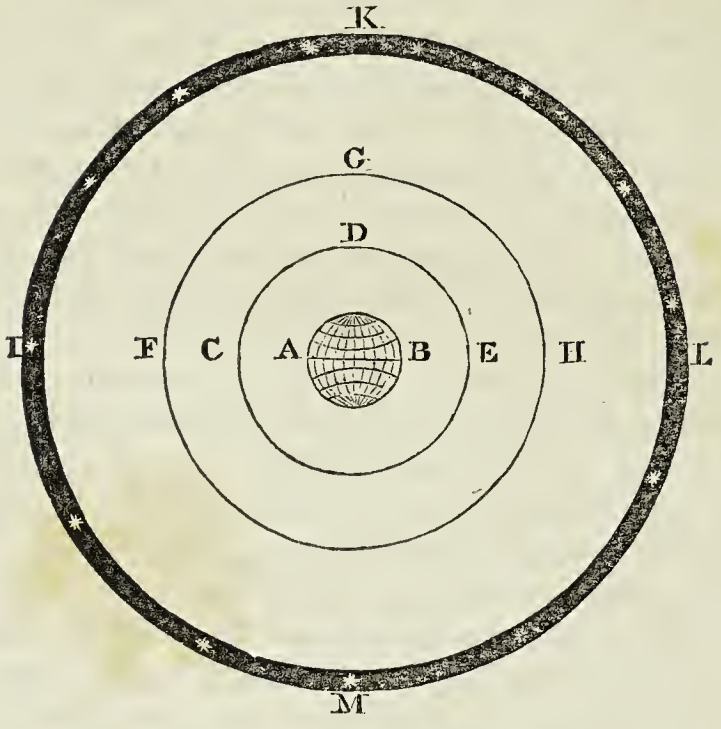
It is presumed that, in the times in which we live, there are few persons who have any doubts that the world in which we dwell is nearly of the figure of a globe, especially when this position can be proved by so many sensible demonstrations. But there are still many who can scarcely be convinced that it is moving along with immense velocity through the regions of space, in company with the other planets. On this subject, therefore, we shall now offer a few considerations, tending to prove that the world we inhabit—however steadfast it may appear to the eye of sense—is, in reality, a moving body, and that all its inhabitants are carried forward with a velocity far greater than any motions we see around us. There are two different motions considered as connected with the earth:—one, by which it is viewed as turning round its axis every twenty-four hours: and another, by which it wings its flight round the sun once every year. In the mean time, I shall chiefly illustrate those arguments by which its diurnal motion may be demonstrated.

1. In the first place, there is one thing of which we are all certain, that motion does actually exist, either in the earth, or in the heavens. We every day behold the sun apparently moving from the eastern towards the western horizon. We

find, likewise, all the stars in the firmament apparently moving in a body round the earth, in the course of twenty-four hours, and in the manner described in the preceding pages. Such observations, which every one has it in his power to make, clearly show, that there is motion somewhere, and the question is—Does this apparent motion really exist in the heavens, or is it the motion of the earth that produces this appearance? Let us suppose, for a moment, that it is the earth which moves. What then, will be the rate of its motion, in turning round its axis, to produce the apparent revolution of the heavens? For if the earth really move round its axis from west to east, the heavens will, of course, appear to revolve around us from east to west. The rate of this motion will depend upon the magnitude of the earth. Now, we know that the earth is a globe, somewhat more than 24,000 miles in circumference; and, consequently, in turning round every twenty-four hours, some portions of its surface must move at least a thousand miles every hour. This is a motion far more rapid than has ever been produced in the smallest bodies by human art; and, therefore, it may appear incredible to some that such a motion can exist in a globe of such vast dimensions as the earth. But, if such persons deny that the earth thus moves, then they *must admit* that the heavens move. There is no alternative; for motion actually exists, either in the one or in the other. Now, if the motion is to be considered as existing in the heavens, let us consider what the rate of this motion must necessarily be. If a small globe, of eighteen inches diameter, were supposed to perform a revolution round its axis in two seconds, and a globe of 2000 yards, or 72,000 inches in diameter, to finish a rotation in the same time, this larger globe would move with a velocity four thousand times greater than the other. In fig. 5, if A B, in the centre, represent the earth, then, if the circle C E revolve round it in a certain time, and the other two circles revolve around it in the same time, it is evident that the circle F H must revolve with a quicker motion than the circle C E, and the circle I L with a still greater velocity in proportion to its greater distance from the centre of motion, A B.

Let us consider, then, what would be the rate of motion of some of the bodies in the heavens, whose distance from the earth is known. The sun is ascertained to be ninety-five millions of miles distant from the earth, and, consequently, were he to move round the earth every day, as he appears

Figure 5.



to do, he would move along a circumference of 597 millions* of miles every day ; that is, at the rate of above twenty-four millions of miles in an hour, 414,000 miles in a minute, and 6900 miles every second. Again, the planet Uranus, at its nearest distance from the earth, is more than 1700 millions of miles distant; and consequently the circumference of its orbit is more than ten thousand six hundred millions of miles. If, therefore, this planet were supposed to move round the earth every day, its motions would be at the rate of 445 millions of miles in an hour,—seven millions four hundred and twenty thousand miles in a minute,—and one hundred and twenty-three thousand six hundred and seventy-seven miles every second. Again, the nearest fixed stars are known not to be within 20,000,000,000,000, or twenty billions of miles from the earth; and consequently their daily circuit round our globe would measure more than 125,000,000,000,000, or one hundred and twenty-five billions of miles ; that is, at the rate of fourteen hundred millions of miles in the space of a single second, or the interval of time which the pendulum of a common clock takes in moving from one side to the other!

* If the circle C D E represent the circle which the sun apparently describes in revolving round the earth, P C, its distance from the centre of the earth, represent 95,000,000 of miles, and the diameter of the circle C E 190,000,000 ; and, as the proportion of the diameter of a circle to its circumference is nearly as 7 to 22, the circumference of the sun's circle, C D E, will be about 597,000,000 of miles, through which he behoved to travel every day, if the earth were at rest.

Stars, at distances a hundred times greater—of which there are many such in our firmament—would move with a rapidity a hundred times swifter; and those still farther removed from us in the depths of immensity, with a velocity far exceeding either human or angelic comprehension. Yet all the stars of heaven appear to move round our globe every twenty-four hours. If the circle C D E (fig. 5) represent the supposed diurnal orbit of the sun; F G H that of Uranus; and I K L M that of some of the fixed stars; then it is evident, that in proportion to the distance of the body from the earth will be the velocity of its motion, if it be supposed to move round the earth every day.

If, therefore, there be any reader disposed to reject the motion of the earth, because it appears incomprehensible, he must necessarily admit of motions ten hundred thousand times greater, and far more incomprehensible,—more especially when we consider that the bodies in the heavens to which we have alluded are incomparably greater than this globe of earth on which we stand,—the planet Uranus being more than eighty times, and the sun more than thirteen hundred thousand times larger than the earth, and the fixed stars, at an average, as large as the sun. Such a rate of motion, in such a number of magnificent luminaries, appears altogether overwhelming, and, I may add, altogether incredible.

The question then which we have to decide is, which of the motions to which we have referred is most probable—the motions of the earth, or of the heavens? Is it really necessary that the whole universe, composed of sun, moon, planets, comets, stars, and nebulæ, should move round our globe with such astonishing velocities, in order to produce the alternate succession of day and night? Reason tells us that it is not. We know that the Almighty does nothing in vain, but employs the most simple means, in order to accomplish the most astonishing and important ends. The succession of day and night can be accomplished by a simple rotation of the earth on its axis, which will completely account for all the apparent diurnal revolutions of the celestial bodies. This we find to be actually the case with the other planets of the solar system. The planet Jupiter is fourteen hundred times larger than the earth, and moves round its axis in less than ten hours, at the rate of 28,000 miles an hour, which is a velocity twenty-eight times greater than that of the earth, supposing it to move round its axis. The planet Saturn is nearly a thousand times larger than our globe, and it revolves round

its axis in ten hours and a half, at the rate of 24,000 miles an hour, in those places situate near its equator. To a spectator placed on these planets, the heavens would appear to revolve around him every ten hours, as they appear to us to revolve every twenty-four hours, but with an apparently more rapid motion; while he himself might suppose, as we are apt to do, that he is actually at rest. The earth, therefore, must be considered as revolving round its axis, in accordance with the arrangements of the other planets of the system to which it belongs; and to suppose otherwise, would be in opposition to all the laws which govern the material universe, and would distort all our ideas of the harmony and order of the works of the Creator.

2. Another consideration which demonstrates the diurnal motion of the earth is this: that such a rate of motion in the heavenly bodies, as has now been stated, though it might be within the limits of Divine power to effect, *would soon shatter the material universe to atoms*, and reduce creation to a chaos. Were a ball of soft wood to be projected from a cannon, at the rate of 800 miles per hour, in a few moments it would be reduced to splinters; and hence the forage and other light substances projected from a piece of ordnance are instantly torn to pieces. What then might be supposed to be the consequences, were a body impelled through the ethereal regions with the velocity of a hundred thousand millions of miles in a minute, as multitudes of the stars behoved to be, were the earth at rest in the centre of the universe? It would undoubtedly reduce to atoms the most compact bodies in creation, although they were composed of substances harder than adamant.

3. Another corroborative argument in support of the motion of the earth is this, that *there is no instance known in the universe of a larger body revolving around a smaller.* We do not find such planets as Jupiter and Saturn revolving around their satellites, or moons; but all those satellites, which are much smaller than these planets, perform their revolutions around them, as the centre of their motions. The earth, which is fifty times greater than the moon, does not revolve around her, but that nocturnal luminary regularly revolves around the earth. The sun does not revolve round the planets Mercury and Venus—which are thousands of times less than that luminary—but they invariably revolve around him as the centre of light and influence. As the sun is one million three hundred thousand times larger than the

earth, it cannot, therefore, be supposed for a moment, that such an enormous globe should revolve, with such an inconceivably rapid motion, around so inconsiderable a ball as the earth; and much less that the whole universe should revolve around it every day. Were the earth not revolving round its axis every day, there would be an infraction of all the laws which govern the system of universal nature; and therefore it is absolutely necessary to admit its motion, in order to direct our views, and to produce conviction of the unity of design, and of the harmony of creation.

4. The last argument I shall mention in the mean time, and which I consider as demonstrative on this subject, is this—that if the earth were at rest, and all the heavenly bodies revolving around it with dreadfully rapid motions, *it would confound all our ideas of the wisdom and intelligence of the Deity.* Wisdom is that perfection of an intelligent agent, which enables him to proportionate one thing to another, and to devise the most appropriate means to accomplish important ends. We should reckon that person foolish in the extreme who should construct, at an enormous expense, a huge piece of machinery for carrying round a grate, and the body of a large building to which it is attached, for the purpose of roasting a small fowl, fixed in the centre of its motions; instead of making the fowl turn round its different sides to the fire. Were the inhabitants of London, or any large town, to attempt to construct machinery to make the whole city move round in a circle, carrying a lamp near the centre to throw light and heat over a ball of only one inch in diameter, when the same purpose could have been easily effected by making the ball itself turn round its axis; we should not hesitate a moment in pronouncing such a scheme as a display of consummate folly. But none of these schemes would be half so preposterous as to suppose the vast universe to move round so inconsiderable a globe as the earth, to produce the alternate succession of day and night, when the same object can be effected by the earth's simply revolving around its axis. Such a device, therefore, cannot form any part of the arrangements of Infinite Wisdom. Can we suppose for a moment, that what would be considered as the consummation of folly in mankind, is characteristic of the plans and operations of the Divinity, or that the great Source of eternal wisdom is to be levelled below the most foolish of men? Such a thought never can be admitted by any of his intelligent offspring, in relation to Him who is designated "THE ONLY WISE GOD,"

who "is wonderful in counsel, and excellent in working," and "who hath established the world by his wisdom, and stretched out the heaven by his understanding." If it could be proved that the earth is at rest, and the whole universe in motion around it, I should scarcely admit that the world was framed by that all-wise Being whose character is delineated in the sacred Scriptures, whose wisdom as far transcends that of man as the heavens are high above the earth.

I have been somewhat particular in exhibiting the arguments which prove that the earth is a moving body, because, in some minds, there is a great hesitation in admitting this fact, and in others, a disposition to receive it merely on the testimony of other men, without understanding the foundation on which it rests; and because right views and conceptions of such facts lead to right conceptions of the operations and the attributes of that almighty Being whom we profess to adore. I shall take an opportunity of stating the arguments which prove the annual motion of the globe round the sun, when we come to describe the earth considered as a planet.

SEC. III.—REFLECTIONS SUGGESTED BY THE MOTIONS OF THE EARTH AND HEAVENS.

We have now endeavoured to prove to the intelligent reader, that the world in which we dwell, with all its continents, islands, oceans, and its numerous population, is continually revolving around its axis to bring about the returns of day and night. It is also flying with a still greater velocity around the sun, to produce the various changes of the seasons. What an august and sublime idea does this suggest for our occasional contemplation! While we are apt to imagine we are sitting in absolute rest in our apartments, we are in reality whirling round towards the east at the rate of hundreds of miles an hour; and are, at the same time, carried through the regions of space with a velocity of sixty-eight thousand miles every hour; so that during every moment, or every pulse that beats within us, we are carried nearly twenty miles from that portion of space we occupied before. When we lie down to sleep in the evening, we are seldom aware that, during our seven hours' repose, we have been carried along through the space of four hundred and seventy thousand miles! When, amidst the gloom of winter, we look forward to the cheering scenes of spring, we must be carried forward

more than a hundred millions of miles, before we can enjoy the pleasures of that season; and when spring arrives, we must be carried, through the voids of space, hundreds of millions more, before we can enjoy the fruits of harvest. During every breath we draw, and every word we speak, we are carried forward in our course thirty, forty, or fifty miles, unconscious of the rapidity of our flight; but the motion is not the less real, because we do not feel it. What should we think if we beheld one of the largest mountains in Scotland flying through the atmosphere, across the island of Great Britain, with a velocity which would carry it from John-o'-Groats to the Land's End, a distance of seven hundred miles, in seven minutes? It would, doubtless, excite universal wonder and astonishment. But this is not one-tenth part of the velocity with which the great globe of the earth, and all that it contains, flies through the boundless regions of space. Were we placed on a fixed point, a thousand miles distant from the earth, and beheld this mighty globe, with all its magnificent scenery and population, thus winging its flight around the sun, and carrying the moon along with it in its rapid career, such a spectacle would overwhelm us with astonishment inexpressible, and even with emotions of terror, and would present to view a scene of sublimity and grandeur beyond the reach of our present conceptions. To angels, and other superior intelligences, when winging their flight from heaven to earth, and through distant worlds, such august scenes may be frequently presented.

Although the heavens do not in reality move round the earth, as they appear to do, yet there are thousands of globes in the celestial regions whose real motions are more swift and astonishing than even those to which we have now referred. The planet Venus moves in its orbit with a velocity of eighty thousand miles an hour; Mercury at the rate of one hundred and nine thousand miles an hour; and the planet Jupiter, which is one thousand four hundred times larger than the earth, at the rate of nearly thirty thousand miles an hour, carrying along with it in its course, four globes, each larger than our moon. Some of the comets have been found to move more than eight hundred thousand miles in the space of an hour; and some of the fixed stars, though apparently at rest, are moving with a velocity of many thousands of miles an hour. In short, we have every reason to believe that there is not a globe in the universe, nor a portion of matter throughout creation, but is in rapid and per-

petual motion through the spaces of infinity, supported by the arm of Omnipotence, and fulfilling the designs for which it was created.

If we inquire into the original cause of these motions, we shall find that no other cause can be assigned but the fiat and the power of that omnipotent Being who at first said, "Let the universe appear," and it started into being. As matter did not make itself, so neither can it move itself; its motion must commence, and can only be continued every moment, by the power of that almighty Being who brought it into existence. He alone who existed from eternity, whose power is uncontrollable, and whose wisdom is unsearchable, is the original Source of all motion, as he is the Source of all life and animation. By his omnipotent arm the planets were at first launched into existence, and impelled in their swift career, and the motion at first communicated, is every moment continued by the incessant agency of the same almighty Power. Were that Power to withdraw its energy, or the subordinate means by which it is appointed to be continued, the universe would soon run into confusion, and creation be transformed into a chaos. But God, who "stretched out the heavens, and laid the foundations of the earth," hath appointed them a decree which they cannot pass, and they continue to this day, according to his ordinances, for all are his servants. Psalm cxix. 91.

What a scene of wonders is presented to view when we contemplate the motions incessantly going forward throughout creation!—that thousands of globes, much larger than our world, are winging their flight with unremitting speed, through the regions of immensity, at a rate which overwhelms the human imagination! What an astonishing idea does this convey of the energies of the Eternal Divinity, who at first launched this earth and all the planetary globes from his powerful hand! He only "spake, and it was done;" and for thousands of years such motions have been continued without intermission! Well may we exclaim, with the inspired writers, "Who can by searching find out God?"—"Who can utter the mighty acts of the Lord? who can show forth all his praise?"

There are certain practical instructions which may be deduced from this subject. The power of God, as displayed in the motions of the earth and heavens, teaches us that nothing can be too hard for Jehovah, and that all the declarations of his word, however wonderful and inexplicable to mortals,

shall, in due time, receive their full accomplishment. We are assured, by the declaration of the sacred oracles, that a period is approaching when all the millions of the human race, whose bodies are now putrefying in the grave, and all the succeeding generations of men till the close of time, shall be reanimated from the tomb, and arrayed in more glorious forms than they now wear. We are also assured that this globe, on which we now reside, is destined to undergo an important and universal change, when its elementary parts "shall melt with fervent heat," and "the earth also, and the works that are therein shall be burned up," as to their present constitution and aspect, and that a new arrangement will take place, in reference to the habitation to be allotted to the righteous. We perceive no symptoms of such changes at present; we have never seen any of the dead rise to life, after their bodies had mingled with the dust, and the ashes of some of them been scattered by the winds over different regions of the sea and land; and therefore doubts are apt to arise in the mind, whether such wonderful transformations are possible to be effected. But all such doubts are at once dispelled, when we consider the perfections of Jehovah as displayed in the structure, and particularly in the movements of the universe, which afford us a sensible demonstration, that nothing, however inexplicable to us, can be beyond the range of Omnipotence. Therefore, we may rest assured that, when the time appointed in the decree of Heaven arrives, that power which carries the earth and all the celestial orbs in their rapid motions through the sky, shall be exerted in reanimating all the generations of mankind, now sleeping in the tomb; in producing a most wonderful change in the aspect of this terraqueous globe; and in causing "new heavens and a new earth" to arise, wherein righteousness shall dwell for ever. For that power which carries thousands of vast globes through the regions of immensity, with velocities of a hundred thousand miles in the short space of an hour, must be more than adequate to accomplish all the glorious scenes and transformations predicted in the records of the Christian revelation. The Christian may therefore rely with unshaken confidence on all the "great and precious promises" contained in the Scriptures of truth, which are given forth by Him whose faithfulness is established in the very heavens, and who "keepeth covenant and mercy with them that love him and keep his commandments to a thousand generations," and therefore cannot fail of ultimately receiving their full accom-

plishment. Well, therefore, may the believer in Christ exclaim—

"If my immortal Saviour lives,
Then my immortal life is sure:
His word a firm foundation gives;
Here let me build and rest secure.

"Here let my faith unshaken dwell:
Immovable the promise stands;
Nor all the powers of earth and hell
Can e'er dissolve the sacred bands.

"Here, O my soul, thy trust repose!
If Jesus is for ever mine
Not death itself, that last of foes,
Shall break a union so Divine."

CHAPTER III.

DESCRIPTION OF THE SUN—OF THE INFERIOR PLANETS —AND OF THE EARTH AND MOON.

When we take a particular survey of the starry heavens, we find that the stars, in general, never shift their positions from each other. They appear to move round us in one compact body, as the figures of the constellations do on a celestial globe, when it is turned round its axis; but the stars belonging to one constellation never move towards those of another, nor change their distances from each other. If we direct our attention to the stars of the Great Bear, for example, (see fig. 1,) we shall find that, at all hours of the day and night, and at every season of the year, they present the same definite figure, and the same relative position to each other, without any sensible variation of distance or magnitude; and the same may be observed from one year to another. Hence, they are usually denominated "the fixed stars." But when we observe the heavens with still more accuracy and minuteness, we shall occasionally perceive a few bodies, having the appearance of stars, which, when carefully watched, for a few weeks or months, will be found shifting their positions with respect to the surrounding stars. In most cases, their motion is towards the east, but not unfrequently towards the west, and, at certain times, no motion can be observed for a considerable number of days. The bodies which are thus

perceived to change their positions among the stars are called PLANETS; which word signifies "wandering stars."

There are ten orbs of this description which have been traced in the heavens, and whose motions have been accurately ascertained. Only five of these bodies are visible to the naked eye: the other five can be seen only with telescopes. The five planets visible to the unassisted eye were known to the ancients, who gave them the following names, derived from the heathen mythology; namely, Mercury, Venus, Mars, Jupiter, and Saturn. The other five were discovered by means of the telescope, within the space of the last seventy years. They are named Vesta, Juno, Ceres, Pallas, and Uranus. By a careful investigation of the motions and other phenomena of these bodies, astronomers have ascertained that they all move round the sun as the centre of their motions; and, along with the earth, and nineteen smaller globes, form one grand and harmonious system, with which we who live on the terraqueous globe are intimately connected. The central orb which enlightens these moving bodies, and by its influence preserves them in harmony and order, is the same sun that enlightens our day, and diffuses life and animation among all the animal and vegetable productions of our globe. These bodies, although they sometimes appear in different and even opposite regions of the heavens, occupy but a very small space, as to the range of their motions, compared with that which is occupied by the fixed stars. The whole assemblage of these moving orbs, including the earth, is what is generally denominated THE SOLAR SYSTEM, of which we shall now proceed to give a general description, beginning at the centre of the system, and proceeding to the different planets as they lie in order.

SEC. I.—THE SUN.

The sun is the grand centre and the animating principle of the planetary system, around which all the planets revolve, at different distances, and in different periods of time; and by whose attracting influence they are retained in their respective orbits. From this source they all derive light and heat, and all the other influences requisite to fit them for being habitable worlds.

Among all the objects of the visible creation, there is none whose beauty is so much admired, and whose benign influence is so generally appreciated, as the sun. Every day this glorious orb visits us with its cheering beams, dispels the

shades of night, and diffuses joy and animation among all the tribes of sensitive existence; without whose powerful energy, our world would soon become a dark and shapeless chaos, without life, order, or enjoyment. But the splendour of this luminary, and the benefits it confers, are so common and so regularly continued, that we are apt to view them with indifference; and we seldom contemplate, with the eye of an enlightened understanding, the wonderful nature of that globe on which surrounding worlds depend for all the comforts and beneficial agencies they enjoy. To the vulgar eye, the solar orb appears only like a flat luminous circle of a few inches diameter; and there are thousands of mankind who consider it in no other light than as a brilliant lamp, of no great size, hung up in the firmament to give us light by day, and to enable us to prosecute our daily labours. Even minds of a more elevated and reflecting cast have seldom entered into all the sublime ideas connected with the nature and properties of this august luminary; and it is questionable whether the greatest astronomer now existing is capable of forming a conception of the magnitude and sublimity of the solar orb, corresponding to its vast extent and its real grandeur, as the soul, and centre, and connecting principle of mighty worlds.

Of the *magnitude* of this stupendous globe arithmetical numbers can scarcely convey to us an adequate idea; but we may, in the first place, state its dimensions in numbers. Its diameter, or a line passing through its centre from one side to another, is found to be 880,000 miles. Its circumference, or a line going quite round it, is 2,764,600 miles. Its surface contains 2,432,800,000,000 of square miles; that is, more than twelve thousand times the number of square miles on our globe. Its solid contents comprehend 356,818,739,200,000,000 or three hundred and fifty-six thousand billions of cubical miles; that is, 1,350,000 times the number of solid miles which the terraqueous globe contains; so that were one million three hundred and fifty thousand globes as large as the earth to be compacted into one globe, it would only equal the size of the sun! Some of these dimensions may be somewhat illustrated as follows: Suppose a person to move round the sun's circumference at the rate of forty-five miles every day, it would require more than one hundred and sixty years before the circuit could be completed. Suppose one were to traverse the whole surface of this luminary, so as to pass over every square mile on its surface, at the rate of sixty miles a day, it would require more than a hundred millions

of years before such an object could be accomplished. It is stated that the splendid view from Mount Etna comprehends a circle two hundred and forty miles in diameter, containing 45,240 square miles. Now this is only the fifty-three millionth part of the surface of the sun; so that more than fifty-three millions of landscapes, such as beheld from the top of Etna, must pass before us ere we could contemplate a surface as extensive as that of the sun. Were we to suppose every such landscape to occupy two hours in the contemplation, it would require twelve thousand two hundred and seventy-five years—without the least intermission—or more than double the time which has elapsed since the Mosaic creation, before the whole surface of this immense globe could be, in this rapid manner, surveyed. The magnitude of this luminary may also be illustrated from the following comparison: The earth contains about two hundred and sixty-four thousand millions of cubical miles; the planet Jupiter is fourteen hundred times larger than the earth; Saturn is about a thousand times; and Uranus about eighty times larger than the earth: yet the sun is found to be more than five hundred times larger than those planets, and all the other planets, moons, and comets of the solar system taken together.

If it be asked why the sun appears so small to our eyes, if it is indeed so immense a globe, it is easily answered, that this is owing to its immense distance from our world. This distance is no less than ninety-five millions of miles,—a distance of which the mind can form only a very inadequate conception. It may be somewhat illustrated, however, as follows: A cannon ball, at its utmost speed, when it leaves the mouth of the cannon, is calculated to fly at the rate of about five hundred miles an hour; but it would require such a moving body—though flying continually with this velocity—twenty-one years and two hundred and forty-five days before it could reach the sun. This may be further illustrated by motions with which we are more familiar. Suppose a steam-carriage to set out from the earth in the direction of the sun, and to move, without intermission, at the rate of four hundred and eighty miles every day, it would require five hundred and forty-seven years before it could traverse the space which intervenes between us and that distant luminary. How wonderful, then, that the sun, at such a distance, should exert his attractive power upon the earth—fructify the soil—raise tides in the ocean—and diffuse light, and heat, and colour, and animation, over all its regions! And not only so, but even on the remotest planet of the system, at the distance

of eighteen hundred millions of miles, similar influences are produced by the agency of this august luminary!

Are we startled at the vast distance and dimensions of the solar orb which we have now stated? and are we apt to doubt whether the representations we have given be accordant with fact? We ought to consider that He who made the sun, and adorned him with the splendour he exhibits, is "THE LORD GOD OMNIPOTENT," the extent of whose power and wisdom none can comprehend; and that the sun required to be of such a magnitude to give stability to the system of which he is the centre; and, according to the laws he hath impressed upon the material world, to retain surrounding worlds in the paths prescribed them, and to dispense to them all those influences which they require. If we are astonished at the magnitude of the sun, how must our admiration be raised when we consider that this globe is only one out of millions of similar globes which exist in the universe! For every star that adorns our firmament is, on good grounds, concluded to be a sun, no less spacious and luminous than that which enlightens our day; and has, doubtless, a retinue of planetary globes revolving around it, as the centre of light and influence.

Nature and physical constitution of the Sun.—Of the real nature of this luminary we have hitherto acquired but very imperfect conceptions. But since the invention of the telescope, our knowledge of its constitution has been somewhat enlarged. We no longer view the sun as a ball of liquid fire, as had sometimes been supposed, but as a solid body, composed of different materials, in which wonderful processes are going forward on an extensive scale, for preparing and perpetuating that light and heat which are destined to cheer and illuminate surrounding worlds. When the sun is viewed by means of a telescope, spots of various kinds are perceived upon its surface. These spots appear first on its eastern margin, when they appear narrow and somewhat obscure; they move gradually onward to the centre of the disk, when they appear largest and most distinct; afterwards they proceed towards the western limb, where they again appear narrow and obscure; and after a period of about thirteen days, from their first appearance on the eastern edge, they disappear from the western limb; and, in many cases, they again appear on the eastern limb, after the same period of thirteen days. But they are frequently somewhat changed in their aspect before they reappear; and, in numerous instances, after disappearing from the sun's western boundary, they are never

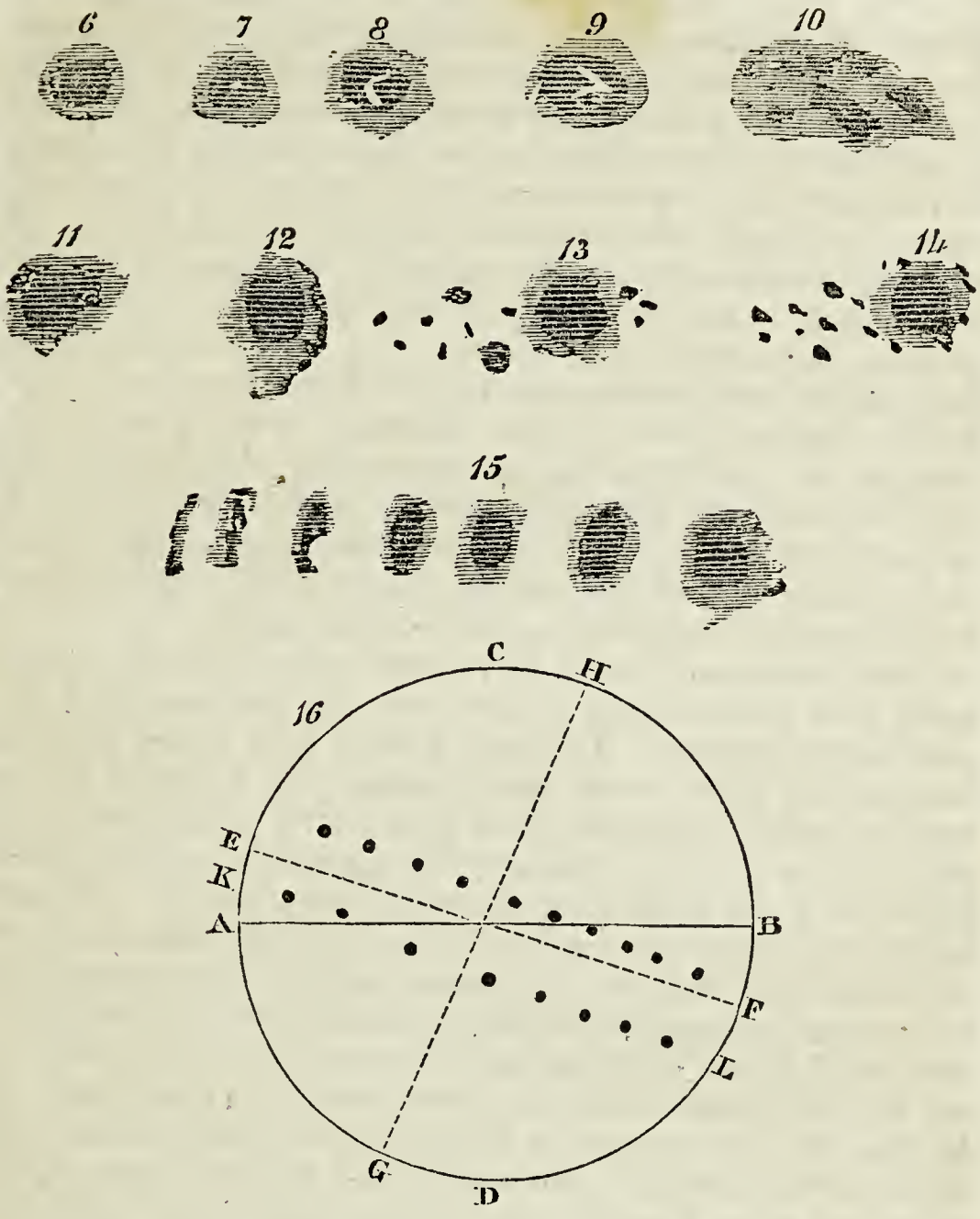
again visible in the same shape; but other spots, at uncertain intervals, are seen diversifying the solar disk; though not unfrequently scarcely a single spot is to be seen over the whole surface of the sun. The spots appearing narrower and less distinct on the eastern and western limbs, is owing to our viewing obliquely these parts of the sun's surface. The conclusions to be deduced from these circumstances are, 1st, that the sun is a globe, and not a flat surface, as it appears to the naked eye, otherwise the spots would appear equally large and distinct on every part of its surface. 2nd, That this luminary moves round its axis in the same direction as the rotation of the planets; for its spots do not shift their places on its disk, but are carried along with the whole body of the sun. The time of the apparent revolution of these spots is 27 days, 8 hours; but the real period of the sun's rotation is 25 days, 9 hours, 56 minutes; and therefore, the places about the sun's equator move at the rate of four thousand five hundred and thirty-two miles an hour.*

The solar spots are of all sizes, and of different shapes: their size is from $\frac{1}{600}$ to $\frac{1}{30}$th of the sun's diameter. The smallest of those spots which can be distinctly seen, are nearly a thousand miles in diameter. Spots, the one-fiftieth part of the diameter of the sun—which we have frequently seen—are 17,600 miles in diameter, or more than double the diameter of the earth; and if the spot be considered only as a plane, and somewhat circular, it will contain more than two hundred and forty-three thousand square miles, which is considerably more than the area of the whole terraqueous globe; and yet sometimes a spot of this vast size will disappear in a few weeks, and not unfrequently in a few days. Sometimes not a single spot is to be seen on the solar disk for weeks and even for months together; at other times, we have seen above one hundred spots of all sizes dispersed over the face of the sun at one time. In such cases, there are generally five or six large spots, such as that alluded to above, accompanied with ten, fifteen, or twenty smaller spots; but, after disappearing at the sun's western limb, it is seldom that they come round again in the same order as before. Some appear to have been altogether dissipated, and others to have changed their shape and relation to surrounding spots, in which they formerly appeared. We have seen spots of nearly 2000 miles in diameter vanish in the course of twenty-two hours:

*This is found by dividing the circumference of the sun = 2,764,600 miles, by the number of hours in which the rotation is performed, namely 610 hours, and the quotient is the rate of motion per hour.

and, on the other hand, on a late occasion, we beheld two spots, each of them larger than the earth, and containing at least three hundred millions of square miles, which were formed near the centre of the solar disk, where no trace of them was seen forty hours before; which circumstances show the amazing rapidity with which these mighty masses are formed, and again rendered invisible to the sight. The portions of the sun's surface where the spots most frequently appear, are those which lie adjacent to its equatorial regions; no spots being ever seen near its northern or southern poles. In some years, these spots have been very numerous, and seldom a week has passed without a few of them having been seen, while in other years, comparatively few have been visible.

These spots, as to their general appearance, resemble a dark nucleus, surrounded with a penumbra, or belt of a lighter shade. This penumbra is generally of a shape nearly corresponding to that of the dark nucleus, or central spot. This fainter belt is plainly perceptible in the larger spots, and when very high powers are applied to the telescope, the umbræ are also visible in the smaller spots. The following representations will convey a general idea of the phenomena of the solar spots. Fig. 6 represents the more common appearance of these spots—a dark central part surrounded by a fainter shade. Figs. 7, 8, 9, represent the appearances of certain spots which exhibit a bright spot, or figure, in the midst of the dark nucleus. Fig. 10 shows a spot, in which various dark spots are surrounded by one common penumbra; figs. 11, 12, spots of different shapes; figs. 13, 14, large spots accompanied or surrounded with dark spots of a much smaller size. This is a very common phenomenon: it is seldom that any large spots are seen without being accompanied with a variety of small spots of different sizes, frequently assuming the appearance of a tail to the large spot. Fig. 15, represents the appearance and progress of a single spot, from the time it appears on the sun's eastern limb till it arrive at the centre of the disk. As the sun moves round an axis which is not perpendicular to the ecliptic, but inclined seven and a half degrees from the perpendicular, so the spots move in a line deviating from the ecliptic, and perpendicular to the sun's axis. Thus in fig. 16, A B represents the ecliptic; D C its axis perpendicular to it; G H the axis of the sun, around which it performs its rotation, deviating seven and a half degrees from D C, the axis of the ecliptic. The spots therefore move in a line E F or K L, which is at right angles with the axis of the sun.



Besides the dark spots whose phenomena we have now described, there are spots which have a bright and mottled appearance, and which it is difficult, in most cases, to distinguish from the general body of the sun. They are chiefly to be seen when they first appear on the eastern margin of the sun, and when they approach near the western limb; but they are seldom or never seen near the middle of the disk. They are most generally seen in connection with clusters of the dark spots, and when they are first seen near the eastern limb, they frequently indicate that dark spots are about to make their appearance. They appear like luminous ridges, and plainly indicate that the sun is not a smooth surface, but is diversified with elevations and depressions, or, in other words, with mountains and vales of a stupendous size, other-

wise we could not perceive them at the remote distance at which we are placed. But what these bright ridges, or corrugations, are—whether immense luminous clouds, or solid bodies—or what purpose they serve in the operations which are going forward in this luminary, we are unable to determine.

The following is a summary of the phenomena of the solar spots. 1. Every spot which has a dark nucleus has also an umbra surrounding it. 2. The boundary between the nucleus and umbra is well defined. 3. The increase of a spot is gradual, the breadth of the nucleus and umbra dilating at the same time; and its decrease is gradual in the same manner. 4. The nucleus, when on the decrease, in many instances, changes its figure by the umbra encroaching upon it; and thus it sometimes happens that the nucleus is divided into two or more nuclei. 5. The exterior boundary of the umbræ never consists of sharp angles, but is always curvilinear. 6. The nucleus vanishes sooner than the umbra.

The conclusions which have been drawn from the phenomena now described, in reference to the constitution of the sun, are as follows: That the central part of the spots is beneath the level of the sun's surface, or, in other words, that the spots are excavations in the body of this luminary, and that the umbra, or shade, which surrounds it, is the shelving sides of this excavation in the luminous matter. According to this view, the nucleus is nothing else than the dark and solid body of the sun appearing through the openings of a luminous atmosphere which surrounds this mighty globe. According to Sir W. Herschel's estimate, this atmosphere is not less than 1840 miles, and not more than 2760 miles in depth. This he regards as the outermost coating of the sun, or his visible surface; and under this superior stratum, he conceived there is another, more dense and highly reflective, which throws back the light of the upper regions, and that this lower atmosphere constitutes the umbra of the spots, and that the dark central parts of the spots, or, the nuclei, are part of the solid matter of which the sun's body is composed. In accordance with such views, the internal part of the sun may be considered as an immense solid ball, not altogether unlike the earth and the other planets; and there is no great improbability in supposing that it is fitted for being the habitation of sensitive and intelligent beings, with constitutions adapted to the situation; and that it may constitute the most glorious habitation connected with the solar system. But whatever may be the real nature and constitution of this luminary, it is evident, from the rapid and extensive changes

which are frequently happening both among the bright and dark spots, that there are forces of prodigious power in continual operation, producing the most astonishing effects, in a short space of time, sometimes in a few hours or minutes, on the surface or in the luminous atmosphere of this great central body. And such changes are, doubtless, necessary for preserving the present constitution of the sun—for enabling him to diffuse light and heat—and to act as the soul of surrounding worlds.

This magnificent luminary is the grand source of light, and heat, and colour to this earth, and to all the planetary globes, with their rings and satellites, which belong to our system. By its energy and influence, it cheers, adorns, and animates a retinue of mighty worlds; directing their motions, and preserving them all in the paths prescribed them, so that none shall wander from their course, ot interfere with others. It is the central bond which unites the moon to the earth; the satellites of Jupiter, Saturn, and Uranus, to their respective primaries, and all the other planets in one grand and harmonious system. On our globe, the benign effects of the sun are numerous and powerful. He is not only the source of illumination, but of all that beautiful diversity of colouring which adorns every terrestrial landscape. Both the earth and sea—the lowest depths of the ocean, and the darkest cavern—feel the effects of his powerful agency. All animated beings rejoice in his presence: when his rays dispel the shades of night, millions of the insect tribes awake and sport in his beams, the birds salute him with their melodious concerts, every thing that breathes feels the effect of his influence; man watches for the morning and rejoices at his approach; for "truly the light is sweet, and a pleasant thing it is for the eyes to behold the sun." The vegetable tribes likewise feel his energy: he gives circulation to the sap in plants and trees; he causes the blossoms and leaves to shoot; the hills and vales to be covered with verdure, and the fruits of the earth to ripen to a golden harvest, for supplying the wants of man and beast. Without the influence of this luminary, darkness and all its gloomy accompaniments would for ever involve this lower creation; all the beauties which now adorn the face of nature would be swept away, the birds would cease their warblings, the flowers would no longer be decked with the gayest colours, nor shed their rich perfumes. Life, activity, and animation would soon cease; and the earth, ere long, would be transformed into a hideous chaos.

Can we reflect on the grandeur and magnitude of this

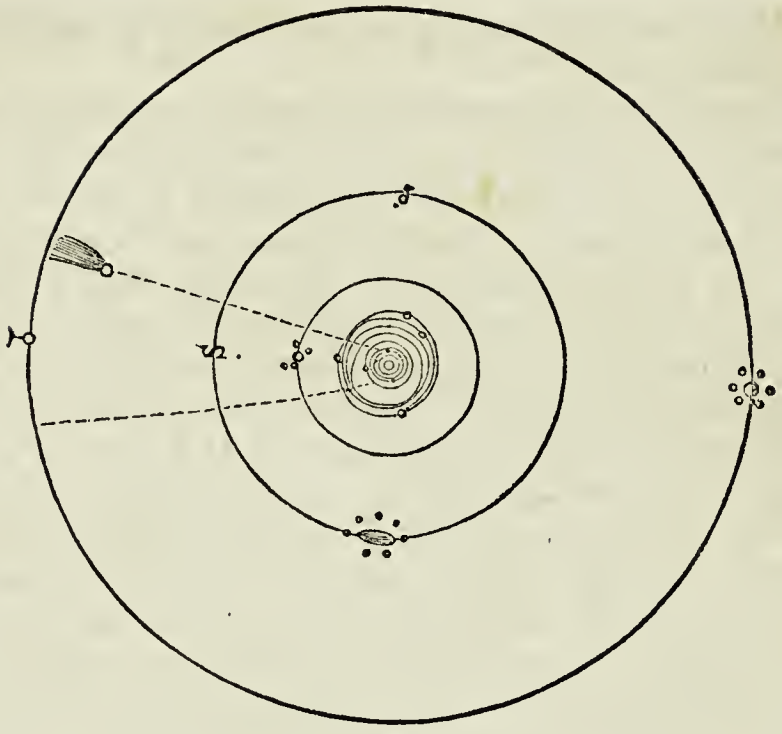
luminary, and the manifold beneficial effects which it produces on our world, without raising our thoughts to Him who at first launched this vast globe from his almighty arm, and still sustains it in all its energies! In all our surveys of the system of nature, it becomes us to raise our views from the effect to the cause, from the creature to the great Creator, and to give to Him "the glory due to his name." This is not only a duty inculcated in Scripture, but is in full accordance with the dictates of true philosophy; which declare, that every phenomenon, and every effect in the universe should be traced up to a cause adequate for its production. And what cause could produce such a stupendous luminary, but that Being who existed from eternity, whose power is uncontrollable and illimitable, and whose "kingdom ruleth over all?" In the formation of this spacious globe we behold a display of Omnipotence which overwhelms our conceptions, and which shows us that nothing, however amazing and incomprehensible, can be beyond the limits of God's power to accomplish. In the numerous beneficial agencies produced by the sun, we have a display of his beneficence, an evidence that the happiness of his creatures is one of the main objects of his creating power, and that "his tender mercies are over all his works." "The day is thine; the night also is thine; thou hast prepared the light and the sun." He hath placed our world at such a distance from this luminary, as neither to dazzle us with excessive brilliancy, nor scorch us with excessive heat, nor freeze us with insufferable cold; but to produce an illumination and a temperature suited to the inhabitants of every clime. The man who can contemplate this glorious object, and feel all the beneficial effects of its influence, without the least emotion of gratitude, reverence, and adoration, scarcely deserves to enjoy the beneficence of his Creator. Let us, then, "give thanks unto the Lord—to him that made great lights—the sun to rule the day: for his mercy endureth for ever." And as the sun enlightens, cheers, and fructifies our globe, and distributes benefits wherever he shines; so let us likewise, according to our power and opportunities, exert all our energies in imparting blessings to our brethren of mankind. As he daily sheds his benign influence around the world; as he rises for the benefit of the ungrateful and the unjust, as well as for the good and the righteous, so let our beneficence be displayed towards men of all characters and nations, that we may prove ourselves to be "the children of the Most High," who, without distinction of persons, distributes bless-

ings without number, among all the ranks of sensitive and intelligent existence.

Notwithstanding the numerous benefits which the sun dispenses to all the inhabitants of our globe, it is a melancholy truth that the greater part of its population is still involved in intellectual darkness and moral debasement, "being alienated from the life of God through the ignorance that is in them." In this respect, it may still be said, as in ancient times, that darkness covers the earth, and gross darkness the majority of the people who inhabit it. While the sun diffuses its splendour around them, their minds are shrouded in a midnight gloom, into which "the light of the knowledge of the glory of God," as it shines "in the face of Jesus Christ," has never penetrated. Before all the effects of light—material and mental—can be fully felt, the Sun of righteousness must arise on the nations "with healing in his beams," to diffuse knowledge, joy, and salvation. His influences are as necessary to our true happiness as those of the material sun to our external comfort and existence. His Spirit irradiates the darkest understandings, purifies the most debased affections, and diffuses gladness and consolation wherever the light of Divine truth shines into the heart. And as the rays of this spiritual Sun are diffused by the truths of revelation, it is our duty to disseminate these truths as extensively as possible among all the kindreds, and families, and tribes, that dwell upon the face of all the earth. Wherever the natural sun shines, the light of Divine truth should be made to shed its influence and its lustre, till light shall spring up to those who sit in darkness and the shadow of death; till "the glory of the Lord shall cover the earth—and all flesh see the salvation of God."

SEC. II.—THE PLANET MERCURY.

Having given a general description of the sun—which is the centre of the planetary orbs, around which they all perform their revolutions, at different distances and in different periods of time, we shall now proceed to give a brief description of what is most interesting in the phenomena of the different planets, beginning with that which is nearest the centre, and proceeding, in order, to those which are more distant. The order in which the orbits of the planets lie from the sun is represented in the following small diagram. The proportional distances of the planets from the centre cannot be distinctly represented, unless upon a diagram of very large extent. In this small figure, the middle point represents the position of the sun. The inner circle next the point which



represents the sun, is the orbit of Mercury, the nearest planet to the sun; the second circle represents the orbit of Venus; the third that of the Earth; the fourth that of Mars; the next circles, which cross each other, represent the orbits of the lately discovered planets: Vesta, Juno, Ceres, and Pallas. Beyond these, the next circle represents the orbit of Jupiter with his satellites, and next to that the orbit of Saturn. The outermost circle is that of Uranus, sometimes distinguished by the names of Herschel, and the Georgium Sidus.

These orbits appear very small, as delineated in this diagram; but they are in reality so immensely large, that the mind can scarcely form any adequate conception of them. The orbit of Mercury, which is the smallest, is more than two hundred and thirty-two millions of miles in circumference. Were a steam carriage to move round it at the rate of twenty miles an hour, it would require more than one thousand three hundred and twenty-four years before it could complete the circuit; yet the planet itself moves around it in the short space of eighty-eight days. The orbit of Uranus, the most distant planet of the system, is eleven thousand three hundred millions of miles in circumference, and three thousand six hundred millions in diameter. To move round this circumference, at the rate of thirty miles an hour, would require above forty-two thousand nine hundred years, or more than seven times the period which has elapsed since the creation of Adam; while the planet itself moves round it in eighty-four years. So that all the arrangements of the Divine Being

are conducted on a scale of magnificence, astonishing to mortals, and corresponding to the infinite majesty and grandeur of Him "who stretched out the heavens by his understanding."

The narrow curve, on the left hand of the figure, crossing the orbits of the planets, represents a portion of the orbit of a comet. The comets move in all directions through the solar system, and their orbits consist of long narrow ellipses, or ovals, some of which extend far beyond the orbits of the most distant planets, where they sometimes remain for a long series of years. These bodies are distinguished by their dim, dusky, and ruddy light, and the long tails, or trains, of light with which they frequently make their appearance. Sometimes they are visible to the naked eye, and make a pretty splendid appearance; but numerous bodies of this description pass near the centre of our system, which are only visible by means of telescopes, and numbers, doubtless, which are never distinguished even by astronomers, except when by chance they happen to direct their telescopes to those portions of the heavens in which they are moving. From December, 1843, to September, 1844, no less than three comets were discovered, but not one of them was visible to the unassisted eye.

Having made these preliminary remarks respecting the general arrangement of the planets and comets, we proceed to a brief description of—

The planet Mercury. This planet, as already noticed, is the nearest to the sun; at least, no planets, nearer this luminary have yet been discovered, though it is not improbable that one or two may exist within the orbit of Mercury. Its name signifies "the swift messenger," and, in point of fact, it is the swiftest moving planet in the solar system, its rate of motion being, at an average, one hundred and nine thousand eight hundred miles an hour, or one thousand eight hundred and thirty miles in a minute; but its rate of motion is somewhat different in different parts of its course, as it moves in an elliptical orbit. Its distance from the sun is about thirty-seven millions of miles, and it performs its revolution around that luminary in eighty-seven days, twenty-three hours, and twenty-five minutes. As to *magnitude*, this planet ranks among the smaller bodies of the system. Its diameter is three thousand two hundred miles, its circumference ten thousand and fifty-three miles, and its surface contains above thirty-two millions of square miles, which is considerably less than the habitable parts of our globe. Were we to compare its size

with that of the sun we should find that it would require nearly twenty-two millions of globes of the size of Mercury to form a globe equal to that of the sun.*

This planet always appears to move in the neighbourhood of the sun. It never appears above twenty-nine degrees distant from the sun, and frequently at the period of its greatest elongations it is not above sixteen or seventeen degrees from that luminary. On this account, it is difficult to be distinguished by the naked eye, unless near the periods of its greatest elongations. The time between its greatest elongations from the sun, varies from one hundred and six to one hundred and thirty days. When it is at its greatest elongation east of the sun, it is seen in the evenings, at a low elevation, not far from the point where the sun sets. When it is west of the sun, it is seen in the morning not far from the point of sunrise. The most favourable seasons for observing it are the spring and autumn, as it is in a higher declination at those seasons than in winter, and the twilight is not so strong nor so long continued as in summer. When viewed by the naked eye, it appears to emit a very white light; and those who would wish to get a view of this planet, when it may be seen, should inspect an almanac, or ephemeris, where the times of its elongations are distinctly stated.† When viewed with a telescope it appears, in the course of its revolutions round the sun, to pass through all the phases of the moon, sometimes appearing as a half-moon, sometimes as a crescent, and at other times with a gibbous phase. When it appears of a half-moon or crescent phase, its enlightened side, like that of the moon, is always turned towards the sun, which proves that it is in itself a dark body, and derives all its light from that luminary. On account of its nearness to

* This is estimated in the following manner—the comparative bulks of spheres are to each other as the cubes of their diameters; therefore, divide the cubes of their diameters by each other, and the quotient shows the number of times the one is contained in the other. In the present instance, multiply the sun's diameter, 880,000 miles, twice into itself, and divide the product by the cube of the diameter of Mercury, 3200 miles, and the quotient will give the number of times that the sun is larger than this planet. Thus the cube of 880,000 is 681,472,000,000,000,000, which divided by 32,768,000,000 the cube of Mercury's diameter = 21 millions and five-sixths, nearly.

† The *Christian Almanac*, published by the "Religious Tract Society," will afford sufficient information on such points, and on various other topics connected with astronomy, and the motions and aspects of the heavenly orbs, especially under the head Phenomena. This almanac is published at the low price of sixpence, contains about 84 closely printed pages, and a vast quantity of useful information on science, religion, philanthropy, domestic economy, acts of Parliament, and a variety of other interesting topics.

the sun, few discoveries have been made on its surface by the telescope. It has been observed, however, that when it appears as a crescent, one of its horns is truncated, or cut off at the point, by which the period of its revolutions round its axis has been determined, which is supposed to be accomplished in twenty-four hours and five minutes. This truncature is doubtless the effect of elevations and depressions on its surface; and hence, some astronomers have concluded that mountains of considerable elevation exist on Mercury, one of which is calculated to be eight English miles in perpendicular altitude. It is supposed, likewise, that it is enveloped with an extremely dense atmosphere.

In consequence of its nearness to the sun—being nearly three times nearer than the earth—the quantity of light is nearly seven times greater than what we receive; and the sun will appear to a spectator in that planet about seven times larger than to us—which circumstances will cause a more brilliant lustre to appear on all the objects on the surface of this planet than appears on the scenery of our globe. Such eyes as ours would be unable to sustain so dazzling a brightness, unless their pupils were contracted to the diameter of one-fiftieth of an inch. That the quantity of heat is in the same proportion, or seven times greater than on the earth, is an opinion by no means probable. It is more probable, from many circumstances connected with our own globe, and from a variety of experiments which have been made on the subject of heat, that the sun's rays may be modified in their action by the nature of the atmosphere, and the constituent elements of which the planet is composed. It is probable that sensible heat depends chiefly on the distribution of the substance of caloric, or the principle of heat, on the surfaces and throughout the atmospheres of the planets, in different quantities, according to the different situations they occupy in the solar system; so that it is possible there may be no more sensible heat felt on the surface of Mercury than on the surface of the earth, or even of Saturn, or Uranus.

Mercury revolves in an elliptical orbit, which is more eccentric than the orbits of the other planets except Juno and Pallas. This is the reason why, at some of its greatest elongations, it is only sixteen degrees from the sun; while at others, it is nearly twenty-nine degrees distant. Its eccentricity, or the distance of the sun from the centre of its orbit, is above seven millions of miles; which is about the one-tenth part of the diameter of its orbit; and this orbit is inclined o the ecliptic, or the plane of the earth's orbit, in an angle of

seven degrees, so that it is sometimes this number of degrees above the level of the ecliptic, and at other times as much below it. The density of this planet is greater than that of any other planet of the system. It has been estimated to be nearly twice the density of the earth, that is about nine times the density of water, or nearly equal to that of lead. Such conclusions are deduced from the laws of gravitation, by which all the planets are directed in their motions.

Transits of Mercury.—At certain periods, this planet is observed to pass across the sun's disk, like a small dark spot. This can happen only at the time of its inferior conjunction with the sun—when it is nearest to the earth—when its enlightened side is turned towards the sun, and its dark hemisphere is turned directly towards the earth; and when the earth, Mercury, and the sun are nearly in one straight line. This passage of Mercury across the solar disk is called its transit, and is considered by astronomers as an interesting phenomenon. If the orbit of this planet were in the same plane with that of the earth, it would transit the sun's disk at every inferior conjunction, or three or four times every year. But as its orbit is inclined to the ecliptic, a transit can happen only when it comes to the inferior conjunction, at the time when it is at or near its nodes, or the points where it crosses the ecliptic, and when the earth is in the same longitude, and this occurs only at intervals of several years. The last visible transit previous to 1845, happened in 1832: another happened in November, 1835, but was invisible in Britain, as the sun was set before its commencement. A visible transit likewise occurred on May 8th, 1845, which began at 19 minutes past 4, P. M., Greenwich time; and the planet arrived near the centre of the disk at 35 minutes past 7, P. M.; but before the planet's egress from the sun's western limb, the sun set to the inhabitants of this country. The next visible transits of Mercury will happen at the following periods: 1848, November 9th; 1861, November 12th; 1868, November 5th; 1878, May 6th. The other transits, during the present century, in 1881, 1891, and 1894, will be invisible in Britain and other European countries, but will be seen in several parts of North and South America, and the islands of the Pacific ocean.

This planet, notwithstanding its comparative smallness, forms a portion of the Divine empire, and is capable of containing a population larger than even that of our globe. Though diminutive in its appearance, and seldom seen by the inhabitants of the earth, we can scarcely doubt that there

are to be found on this planet millions of sentient and intelligent beings—perhaps far superior in dignity to man—with constitutions fitted for that sphere in which Providence has placed them, and with mental powers which qualify them to know, to love, and to adore their great Creator. For it may be considered as an axiom, that the material universe was created, and is still preserved in existence, chiefly for the sake of sensitive and intellectual natures, to afford them the means of happiness, and to give them a sensible display of the character and attributes of the Eternal Divinity.

SEC. III.—ON THE PLANET VENUS.

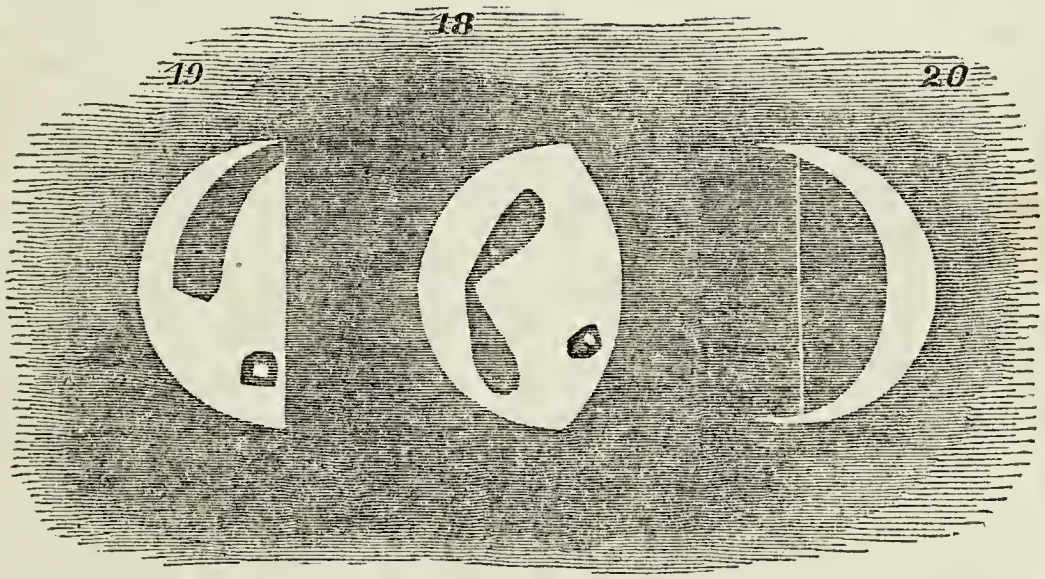
Next to Mercury, in the order of the system, is the planet Venus. To the naked eye it appears the most beautiful and splendid star in the heavens, and has been distinguished both in ancient and modern times as the morning and evening star, because in one part of its course, it makes its appearance, in the west, in the evening, before any other star is visible; and, in another part of its course, it appears in the east in the morning, ushering in the dawn, and giving notice of the approach of the rising sun. Its distance from the sun is reckoned at sixty-eight millions of miles, being thirty-one millions of miles from the orbit of Mercury, and about twenty-seven millions of miles from the earth at its nearest approach to it. At this distance it is nearer the earth than any other celestial body can approach, the moon only excepted. In respect of *magnitude*, it is found to be 7800 miles in diameter, or very nearly the size of our globe. Its surface contains one hundred and ninety-one millions of square miles, and the quantity of light it receives from the sun is nearly double of that which falls upon the earth, on account of its greater nearness to the sun, so that that luminary will appear from its surface twice as large as it does to us. From a variety of observations which have been made on this planet, it appears that it has a rotation on its axis, which is accomplished in the period of 23 hours, 21 minutes; and as the period of the earth's rotation is 23 hours, 56 minutes, its day is, of course, 35 minutes shorter than ours.

Discoveries made on Venus by the telescope.—The first time the telescope was directed to this planet was in the year 1610, by the celebrated Galileo, who had just a little before constructed one of the first telescopes. The chief discovery he then made was, that this planet, in the course of its revolution round the sun, passed through all the phases of the moon, sometimes appearing as a crescent, or like the moon

when three or four days old, sometimes like a half-moon, and at other times with a gibbous phase, or like the moon three or four days before the full. That the planet presents such phases to our eye is a plain proof that it does not move round the earth as its centre of motion, as the ancients supposed, but round the sun, in an orbit which lies within the orbit of the earth. For if it moved in an orbit exterior to that of the earth, it never could present to us either a half-moon or a crescent phase. At the period to which we allude, the greater part of the learned had adopted the vulgar opinion which so long prevailed, that the earth is at rest in the centre of the universe, and that all the planets revolve around it. It was objected to the Copernican system, which supposes the earth to be one of the planets—and which had been recently broached—that if this were the case, the planets Mercury and Venus would appear with all the phases of the moon. This was fully admitted; but it could never be exhibited to the organs of vision before the telescope was invented. When Galileo had published this and several other discoveries, the senators of Venice, who were most of them eminent for their love of learning, invited this astronomer to come, and in their presence make a trial of his new instrument. He complied with their request; and, on a fine, clear, and serene evening, mounted his telescope on the tower of St. Mark, and showed them several of the discoveries he had made, and particularly the appearance of Venus, which was then near the point of its greatest elongation from the sun. One senator after another beheld the planet through the telescope, and all were surprised that more than half of its hemisphere was obscured; that it did not appear round as most of the other heavenly orbs, but inclining to a crescent, with points, or horns, at its opposite sides. Upon this Galileo proceeded to show how this phenomenon furnished a demonstrative proof of the Copernican system of the universe. That night was fatal to the ancient systems maintained in the schools; and from that period, the true system of the world began to be recognised by all intelligent and unprejudiced minds, and, in the midst of every opposition, to be extensively propagated through the world.

After the telescope was improved, and its length and magnifying powers increased, more particular observations began to be made on the surface of Venus. Cassini, an Italian astronomer, with instruments of a large size, on October 14th, 1666, at $5^h\ 45^m$ P. M., saw a small bright spot, near the section between the dark and bright side of the planet; at the

same time he noticed two dark oblong spots nearer the other side of the disk, as represented in fig. 18. On the 20th of April, 1667, in the morning, a little before sunrise, he perceived, on the disk of the planet, then half enlightened, a bright spot near the section and toward the lower horn; and nearer to the northern horn he saw a darkish oblong spot, as represented in fig. 19; and after sunrise, he perceived that the bright spot was advanced considerably from the southern horn; and from this and several subsequent observations, he had a plain proof of the rotation of the planet, which he afterwards determined to be in the space of somewhat more than twenty-three hours. For many years after this period, we have few recorded observations of these spots; and, indeed, they are very difficult to be perceived, on account of the extreme brilliancy which this planet exhibits, and the undulations of the atmosphere, when viewed at a low altitude in the evening. The best time for viewing the surface of this planet is in the daytime, when it is near the meridian, by means of large equatorial telescopes.

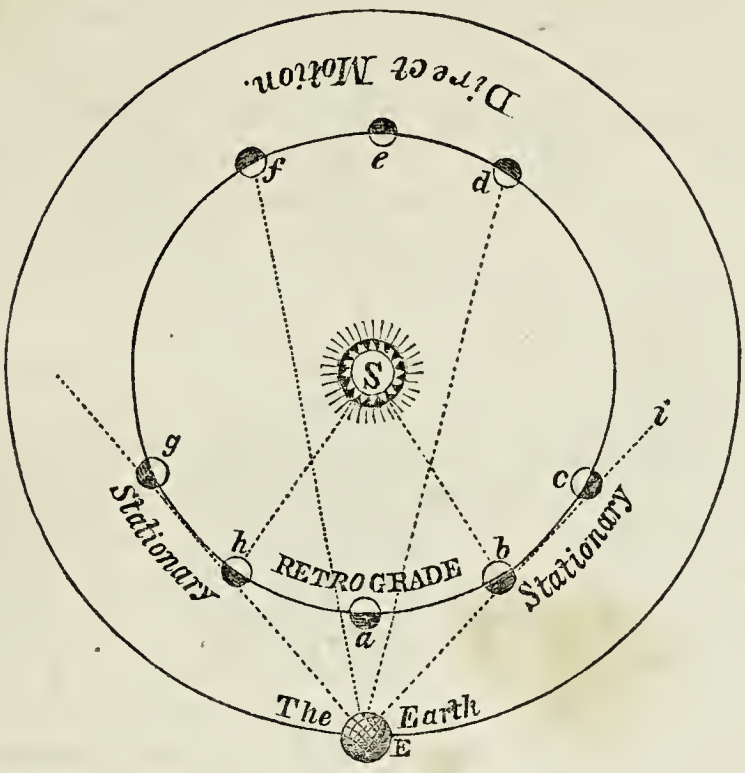


M. Schroeter, a late celebrated German astronomer, made a variety of observations on this planet, from which he has deduced several important conclusions. He discovered the twilight of Venus, or the stretching of a faint light beyond the semicircle which ought to be alone directly enlightened, as shown at fig. 20, where the cusps, or horns, seem to stretch into the dark hemisphere. He deduced from this, and other observations, that Venus has an atmosphere of considerable extent, the densest part of which is above three miles high. A similar conclusion was deduced by a variety of observers in different places, when viewing the transit of this planet in

1761. At the time when the planet entered on the sun's disk, and when it was about to emerge from the eastern limb, a faint penumbra or dusky shade was seen surrounding the planet, which indicated an atmosphere of considerable height. M. Schroeter likewise detected several mountain ridges, and elevations of great magnitude on the surface of Venus. Such elevations are ascertained from the length of their shadows. He estimated the perpendicular height of one of these mountains to be ten and a half English miles, and of another no less than nineteen miles. Although these elevations so far surpass the height of the highest mountains on our globe, yet such estimates are not to be considered on this account as improbable. For, in nature, there is an infinite variety, and every planet differs from another in its arrangements. Such lofty elevations will add to the sublimity of nature on the surface of this planet, and will afford, from their summits, prospects far more extensive and sublime than we can at present conceive.

Apparent motions of Venus.—Were the planets viewed from the sun, the centre of the system, their motions would appear nearly uniform, and in one direction, from west to east. But when viewed from the earth, or any other planet, their motions appear very irregular, and in different directions, and sometimes they appear to make a pause in their course. Hence the apparent motions of the planets, as viewed from the earth, are said to be either direct, retrograde, or stationary. This may be illustrated in the apparent motions of Venus, and what is here stated of this planet will equally apply to the motion of Mercury. Thus, in fig. 21, let S represent the sun, E the earth, and *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, the planet Venus in different parts of its orbit, as seen from the earth at E. When it is at *a*, it is said to be in its inferior conjunction with the sun, because it is then nearly in a line with the sun; and were it visible, it would be seen nearly in the same part of the heavens as the sun. But at this time its dark hemisphere is turned towards the earth, and therefore is invisible unless it should happen, as it sometimes does, to pass across the disk of the sun. In moving from *a* to *b*, its motion is retrograde, or towards the west. In moving from *b* to *c*, it appears stationary, because the tangent line, or visual ray *b i*, will appear for some time to coincide with the orbit of the planet. At *c* the planet is said to be at its greatest western elongation from the sun, when it appears in its greatest brightness as a morning star. In passing from *c* to *d*, and from *d* to *e*, its motion is direct, or from west to east. At *e* is

Figure 21.



the point of its superior conjunction, when it is again nearly in a line with the sun, and when its full enlightened hemisphere is turned towards the earth. But at this point it is the whole diameter of its orbit, or one hundred and thirty-six millions of miles farther from the earth than when it was at *a*, and therefore appears smaller near this position than when only the one-fourth of its enlightened side is seen. From *e* to *f*, and from *f* to *g*, the motion is still direct; from *g* to *h*, it is again stationary, and from *h* to *a* retrograde.

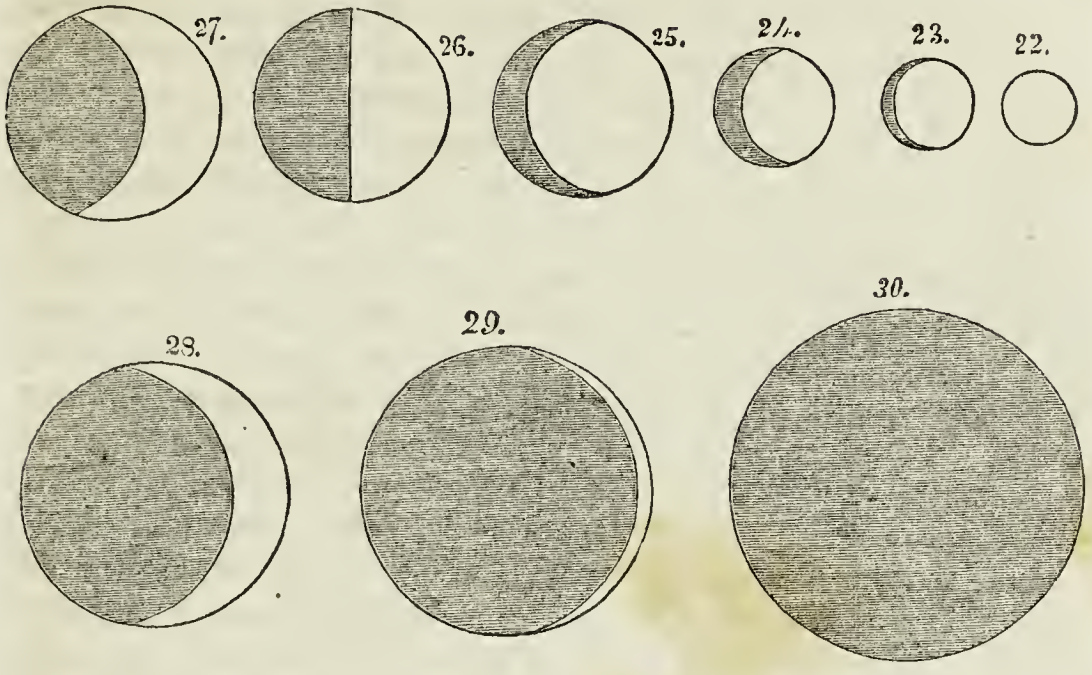
In regard to the *phases* of Venus we may add the following remarks. When the planet is at *e*, at its superior conjunction, if it could then be seen,* it would present a full enlightened hemisphere. As it moves from *e* to *f*, it gradually comes into view as an evening star, and at first appears very

* It has been frequently asserted by astronomical writers that this planet cannot be seen at its superior conjunction. The author of this volume, however, in the course of his observations on the heavenly bodies in the daytime, had an opportunity, on the 2d of October, 1843, of seeing this planet within a few minutes of the time of its superior conjunction, when it was only 58 minutes, or less than 1 degree, from the sun's margin. It was viewed with a three-feet-and-a-half achromatic telescope, magnifying 95 times, and appeared round and pretty distinct, though partly immersed in the solar rays. This circumstance proves that the surface of Venus reflects the solar rays with peculiar brilliancy, more than that of any other planet. For a more particular account of this observation, see "Edinburgh New Philosophical Journal" for January, 1844.

low near the point of the horizon where the sun sets. Its motion appears slow on account of its distance from the earth, and it is sometimes two or three months, after passing the point of its conjunction, before it becomes distinctly visible to the naked eye. When it comes to the point *f* it exhibits a gibbous phase, as seen by the telescope. As it moves onward towards *g*, its apparent size increases, and its gibbous phase gradually declines to that of a half-moon. At *g* it appears like a half-moon inclining to a crescent. About this point of its orbit is the period of its greatest brilliancy, and, in certain years, when in this position, it may be seen in the daytime by the naked eye. At the point *h*, it appears of a crescent form, and while moving from *h* to *a*, the point of its inferior conjunction, its crescent becomes more slender, but at the same time more expansive, till it appears like the crescent of the moon when she is less than two days old. At *a*, the dark side of the planet is turned towards the earth, and consequently invisible. The period employed in passing through these changes, from *e* to *a*, is about nine months and a half. In passing through the other semicircle from *a* to *b*, *c*, *d*, *e*, it becomes a morning star, and, a few days after the conjunction, is seen in the east preceding the rising sun. In proceeding from *a* to *b* and *c*, its apparent motion is rapid, and it presents a crescent phase; at *c* it appears like a half-moon, and in the remaining part of its course to *e* its phase is gibbous, till it arrives at the superior conjunction, when it again presents a full enlightened hemisphere. The time employed in moving from the inferior to the superior conjunction is, as formerly, about nine months and a half.

The following figures represent the phases of this planet, and its gradual increase of apparent size from the period of its superior conjunction to its inferior. Fig. 22 is its phase as a full enlightened hemisphere, and its proportional size when compared with fig. 30, which represents it, when nearest the earth at its inferior conjunction. At this time, it is five times nearer, and consequently five times larger in diameter, and twenty-five times larger in surface than it appears at its superior conjunction. Figs. 23, 24, 25, represent different degrees of its gibbous phase; 26, its half-moon phase; 27, 28, 29, its crescent phase; where it will be seen, that as the breadth of the crescent diminishes, its expansion and length increase, as it is then approaching nearer the earth. Fig. 30 represents its dark side turned towards us at the inferior conjunction. In moving from the inferior to the superior conjunction, it passes through all these phases in a reverse order.

First it appears as 29, then as 28, and till it arrives at the phase fig. 22.



We shall state only the following additional facts respecting this planet. The period of its revolution round the sun is in 224 days, 16 hours, during which time it accomplishes a course of 434 millions of miles, at the rate of eighty thousand miles an hour. Its orbit is inclined to the ecliptic in an angle of three degrees twenty-three minutes and a half, and the eccentricity of its orbit is less than half a million of miles, or about the $\frac{1}{276}$th of its diameter. On the ground of certain observations, it has been supposed that it is attended with a satellite; but such a body, if it exist, is seldom seen, and therefore its existence is considered as uncertain. In its elongations, it never removes farther from the sun than from forty-five degrees to forty-seven degrees. If its enlightened side were turned towards us when it is nearest the earth, it would present a surface twenty-five times larger than it generally does, and shine with the splendour of a small moon; but, at that time, its dark side is turned to the earth. To an inhabitant of Venus, Mercury will appear as a morning and evening star, with more splendour than it does to us; and the earth, when nearest to Venus, whill shine forth with a splendour nearly ten times greater than either Jupiter or Venus does to us. This planet, like Mercury, sometimes makes a transit across the disk of the sun. The last transit happened in 1769, and the next will take place on December 9, 1874, at eight minutes past four, A. M., which will be invisible in Britain, and in most European countries; but, as it is a phenomenon of great importance in astronomy, British astrono-

mers will, doubtless, be sent to observe it in those countries where it will be visible.

This beautiful planet, distinguished from all the other stars by its superior brilliancy, is occasionally alluded to by the sacred writers, as the "son of the morning"—"the day star," and "the bright and morning star:" emblematical of the Redeemer of mankind, giving light to the world after a long night of superstition and darkness, and of its cheering influence on the minds of sinful men, when the "day star" from on high hath arisen in their hearts. When viewing the bright luminaries of the sky, and especially the morning star, and when we consider the beautiful order and arrangement of these orbs, the placid influences they diffuse, and the harmony with which all their movements are performed, a contemplative mind can scarcely refrain from contrasting such scenes with the darkness and disorder which prevail in the moral world. While the sun diffuses his splendours by day, and the moon and the stars shed their mild radiance by night, it is still necessary to the happiness of our world that intellectual light and sacred joy should be diffused over the minds of its inhabitants—of which the light of these luminaries is designed to serve as an emblem. When the morning star makes its appearance near the eastern horizon, it is a sign that the sun will, ere long, arise, and that the darkness of night will soon be dispelled. When the "day star" arises on the benighted mind, it intimates that gloom and darkness, with all their miserable accompaniments, formerly brooded over it: but now that the light of Divine truth has begun to irradiate the darkness, it is a sign that this light will still increase, and shine more and more unto the perfect day," till at length it blend itself with the glories of the celestial world, where the "sun shall no more go down," where the Lord God shall be an everlasting light, and where the days of darkness and "mourning shall be ended."

SEC. IV.—THE EARTH: CONSIDERED AS A PLANETARY BODY.

(1.)—*General view of the Earth's surface, atmosphere, magnitude, and method of finding its dimensions.*

It may seem strange to some readers that this world on which we reside should be considered a planetary orb; as, at first view, it appears to bear no resemblance to any of the orbs that appear in our nocturnal sky. The planets, as they are seen in the heavens, by the unassisted eye, appear only as comparatively small points of light; whereas the earth, from whatever point it is viewed, appears the largest body

our eyes can anywhere behold, and when we traverse its surface, either by sea or land, there appear no boundaries to its dimensions. From the positions in which we are permitted to view any portion of the earth—even when we ascend several miles above its surface in balloons—it exhibits no luminous aspect such as that which the celestial bodies present; so that, at first view, we might be apt to suppose that no similarity can exist between our sublunary world and the orbs of heaven. Besides, the celestial orbs are apparently in rapid motion from one region to another, while the earth, as a whole, appears to be at rest in the centre of the celestial motions. Whether we sit in our apartments, or walk in the fields, we feel no motion in the solid earth which supports us, and are apt to imagine that the portion of the globe on which we dwell remains invariably in the same point of infinite space. We perceive no motions connected with our world but those which are produced by the rivers, the ocean, the atmosphere, and subterranean concussions, and those which are the result of the various processes of the arts—the flux and reflux of the sea—the flowing streams—the roaring cataracts—the stormy winds—the waving forests—the ships moving on the face of the deep—and the steam-carriages, with their hundreds of passengers flying along the railway course. There is not, perhaps, one out of a thousand of the earth's inhabitants that has the least conception that—besides every other movement of which he is susceptible—he is carried along through the regions of infinite space with the rapidity of thousands of miles every hour. Yet this is a fact which is not merely probable, but certain, and can be demonstrated to the conviction of every one who is willing and qualified to enter into such investigations.

Could we take our station on the surface of the moon, we should behold the earth hanging like a great globe in the firmament, appearing with a surface about thirteen times larger than the moon does to us, and turning round its different sides to our eye—sometimes presenting the view of America and the Pacific Ocean, and at other times Asia, Africa, Europe, and the Atlantic—sometimes appearing like a large crescent, or half-moon, and at other times with a full enlightened hemisphere. Were we placed on the surface of Venus, we should behold the globe on which we live appearing in the azure sky like a large bright star, as that planet appears to us when an evening or morning star; and the moon, which appears so large in our firmament would be seen only like a very small star, very near the earth, and constantly moving around it. At certain times, the earth

would appear nearly ten times larger than Venus does to us, and would present the appearance of a small brilliant moon. Were we placed on the planet Mars, which is much further from the sun than Venus, the Earth would appear alternately as a morning and evening star, exhibiting different phases, as Venus does to us, but with a less degree of size and splendour. It might not, perhaps, shine with so much brilliancy as Venus, but it would probably appear with a lustre similar to that which Mars presents to us. Nor need it be wondered at that the earth should appear as a luminous body from such distant positions; for we have demonstrative proof that Venus, Mars, and all the other planets, though they appear like shining orbs, are in reality dark bodies like the earth, and have no light of their own but what they receive from the sun; and it is only when the portions of their sides which are enlightened by the sun are turned to us that they are seen in the heavens. On some occasions, the dark side of Venus is completely turned towards the earth, and then she is invisible; and sometimes, when in this position, has been seen, like a dark spot, to pass across the face of the sun. These and other circumstances demonstrate that the planets are in themselves dark bodies, and shine only by reflection; and consequently that the earth, though a dark body, will appear to shine at a distance by reflecting the solar rays which fall upon it, as the moon does to us.

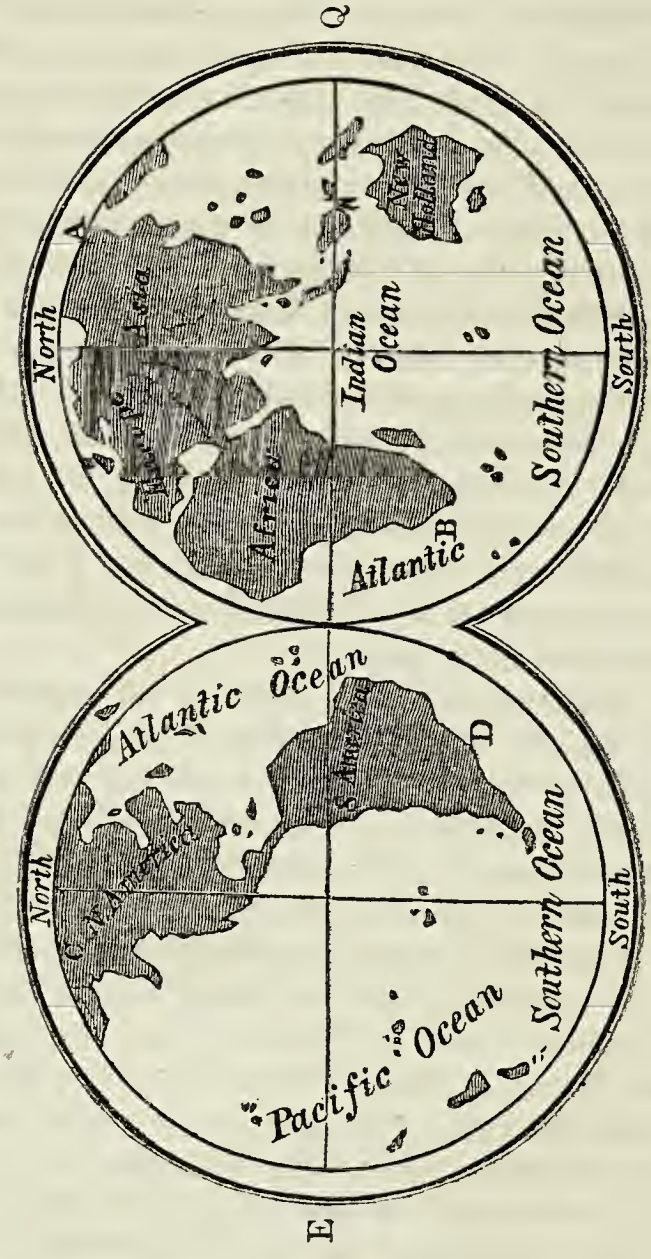
We have already proved, that, as a planet, the earth turns round its axis every twenty-four hours; and, in the sequel, we shall endeavour to show that it also moves round the sun in company with the other planets. In the mean time, we may take a brief view of the surface of our globe, which, in some of its features, may, perhaps, resemble those of some of the other planetary worlds.

When we cast our eyes around us, and take a general survey of the surface of the earth, thousands of objects present themselves to the view which demand attention. One of the most obvious and common arrangements which we behold in almost every country, is the verdant covering of the earth, which is formed by an assemblage of herbs, plants, shrubs, and trees of various shades, which diversify the landscape, and refresh the organs of vision; for there is no colour so pleasing, and which refreshes the eye so much as the various shades of green. When we enlarge the circle of our view by travelling through different countries, we behold objects of a more grand and magnificent description; ranges of mountains, hundreds of miles in length, with their summits

rising above the clouds, presenting a scene of rugged grandeur and sublimity; rivers, rolling their vast masses of waters, in courses of hundreds or thousands of miles towards the ocean, in which they are absorbed; the ocean itself, in its numerous windings, spreading its immense sheet of waters over more than half the globe, rising and subsiding at certain intervals, and forming a medium of communication between the most distant regions of the globe. In various regions of the earth, we behold expansive lakes and inland seas diversified with numerous islands, lofty and abrupt precipices, capes and promontories, dashing cataracts, unfathomable caverns, rapid whirlpools, avalanches hurling down the declivities of lofty mountains, the icebergs of the polar regions, the luxuriant scenes of the torrid zone, and numerous volcanoes surrounded wtih smoke, and pouring forth from their craters ashes, flames, red-hot stones, and streams of melted lava on the surrounding regions.

When we contemplate our globe in its largest and most general features, we find its surface divided from north to south by two large bands of earth, and two still larger bands of water, which exhibit a somewhat irregular appearance, presenting a number of wavings and indentations, and a great difference of breadth in different places. The first band of earth is the Eastern Continent, comprehending Europe, Asia, and Africa, the greatest length of which is in a line beginning about the northern part of Tartary, and extending to the Cape of Good Hope, or from A to B, fig. 31, which line measures about 10,000 miles from north-east to south-west. This body of land contains thirty-six millions of square miles, forming nearly one-fifth of the surface of the terraqueous globe. The other band of earth is the Western Continent, which comprehends North and South America. Its greatest length is in a line from the mouth of the river Plata, in South America, to the land beyond Hudson's bay, or from C to D. This line measures eight thousand miles; and the whole of this continent contains fourteen millions of square miles, being little more than one-third of the western continent. South-east of the western continent is a large body of land, which may be considered as a third continent; namely, New Holland, which is 2400 miles in length, and 1800 in breadth, and contains nearly three millions of square miles. Besides the bands of earth now specified, there are numerous extensive portions of land dispersed throughout the ocean, such as the islands of Madagascar, Sumatra, Borneo, New Guinea, Great Britain, Ireland, and hundreds of others.

Figure 31.



Between the two large continents now stated, lie two immense bands of water, which are called the Pacific and the Atlantic oceans. The Pacific is at least 11,000 miles from north to south, and 10,000 miles in breadth from east to west. The Atlantic is about 3000 miles broad from east to west, and more than 10,000 miles in length from north to south. It lies between the western shores of Europe and Africa, and the eastern shores of America. The Pacific occupies the whole range between the western coasts of America and the eastern coasts of Asia, occupying nearly the one-half of the globe. The relative positions of these continents and oceans will be seen by an inspection of fig. 31, where it may be noticed that the projections of the eastern side of the Ameri-

can continent nearly correspond with the indentations of the western side of the eastern continent; so that, if we could conceive the two continents brought together, they would nearly correspond, so as to form one compact continent, with two or three small gulfs between them. The following are nearly the dimensions of the different oceans. The Pacific covers eighty millions of square miles; which is far more than the extent of all the dry land on the face of the earth. The Atlantic covers twenty-five millions; the Indian ocean thirteen millions; the Southern ocean twenty-five millions; the Northern ocean five-millions; the Mediterranean one million; the Black Sea 170,000 square miles; the Baltic 175,000; the North Sea 160,000. And if, as La Place has estimated, the tides demand an average depth of three miles, the whole ocean will contain 450 millions of cubic miles. The whole surface of the ocean, then, contains about 149 millions of square miles, which is more than three times greater than the surface of the land, which contains only forty-nine millions of square miles.

Around this vast body of land and water the Creator has thrown an atmosphere, or body of air, which is as essential to the existence and comfort of the living beings that dwell on its surface, as any other arrangement respecting our world. The denser part of this body of air extends to the height of about forty-five miles above the surface of the earth, but its density gradually decreases in proportion as we ascend into its higher regions; and at a certain height it is unfit for respiration and giving play to the animal functions. This atmosphere, though almost impalpable to our senses, is now ascertained to be a compound substance, composed of two very different and almost opposite substances, as to their qualities. One of its ingredients, which forms about four-fifths of the whole atmosphere, is of such a nature that no fire will burn in it, and if man or other animals breathe it, life is almost instantly extinguished. The other ingredient, which forms only one-fifth of the atmosphere, is the principle of combustion, and produces the most rapid and splendid deflagration of all combustible substances, and even a steel wire, made red hot, if plunged into this species of air, will take fire and burn with the utmost brilliancy. Animals might breathe it for some time without much annoyance; but it would soon waste the functions of the animal system. It is by an admirable combination of these two opposite principles that the air we breathe is constituted; and in this combination, the wisdom and goodness of our beneficent Creator is clearly manifested; for had these principles been combined in a very

different proportion, pain, suffocation, or death might have been produced in all animals that breathed it. It is in this atmosphere that the birds fly, and the clouds are suspended —where rain, hail, and snow are formed—where a portion of the ocean, of the seas, and of the rivers, is continually ascending, to form those clouds which water and fructify the earth—it is the medium in which whirlwinds rage, and lightnings flash, and thunders roll; and were it swept from the earth, or were its constituent principles materially changed, every living being would soon disappear from all the regions of earth, air, and sea. Were the Creator disposed to destroy the human race on account of their transgressions, he has only to extract one of the ingredients which compose the atmosphere which surrounds us, and the awful catastrophe is at once accomplished; so that, in his "hand is the soul of every living thing, and the breath of all mankind." But his forbearance, in this respect, is a palpable evidence that he is "slow to anger," "merciful and gracious," "abundant in goodness," and that "his tender mercies are over all his works."

In regard to the *magnitude* of the earth, it may be stated that its circumference, or a line going quite round it, measures about 24,912 miles; and, of course, its diameter, or a line passing from one side to another through its centre, measures 7930 miles,* and the number of square miles on its surface is about 197 millions. It has been ascertained, by various experiments and measurements, that the earth, strictly speaking, is not exactly of the shape of a globe, but of an oblate spheroid, being somewhat flattened at the poles, and having its polar diameter about twenty-six miles shorter than the diameter passing through the equator. But the difference is so small, compared with the whole bulk of the earth, that though a spheroid were constructed of the exact shape of the earth, and fifteen feet in diameter, it could not be distinguished by the eye from a common globe.

To some readers it may appear somewhat strange that we should speak with so much confidence of the bulk and dimen-

* As the circumference of a circle or globe is found by mathematicians to bear a certain definite proportion to the diameter—when the one is known the other is easily determined by calculation. The proportion of the circumference of a circle to its diameter is nearly as 22 to 7—more accurately as 3.1416 to 1. Therefore, if we multiply the circumference by 7, and divide the product by 22, we obtain the diameter, nearly. And if we multiply the diameter by 22, and divide by 7, we obtain the circumference. But we obtain the result more accurately by multiplying the diameter by 3.1416, in order to obtain the circumference; and by dividing the circumference by 3.1416, to obtain the diameter.

sions of the world we live in, which has never yet been completely explored; and they may, perhaps, wish to know how it is possible to determine its magnitude, figure, and other properties and relations. It must be confessed that to measure the earth, and determine its magnitude, and its exact figure, is one of the most wonderful enterprises which has ever been undertaken by man. How shall a creature, only six feet high, whose longest measures are yards, poles, and chains, be able to traverse every region of this great world, and measure its dimensions? His stature and his longest measures are, when compared with the whole earth, but as a grain of sand to a range of mountains. Besides, there are portions of the earth which have never yet been reached either by sea or land; and although he were to carry his measuring lines along with him, and extend them to furlongs, miles, and leagues, yet he could not go round the circumference of the earth to obtain its exact measure. Mountains, rivers, seas, and oceans, and many other obstacles would be continual impediments in his way, and would soon put an entire stop to his progress, and the attainment of his object. But, notwithstanding such difficulties, man, by the exercise of his rational powers, and the knowledge he has acquired of the positions and motions of the heavenly bodies, has been enabled to determine, to a very near approximation, the exact dimensions of his earthly habitation, without putting himself to the trouble of travelling to the most distant regions, or even removing from the land of his nativity.

When the earth was ascertained to be nearly of a globular figure, and when the method was discovered of finding the distance of any place from the equator,* or, in other words, its latitude, a foundation was laid for finding the circumference, and other dimensions of the globe. Every circle, or every circumference of a sphere, whether great or small, is divided into three hundred and sixty equal parts. This number, three hundred and sixty, is arbitrary, and any other number, such as four hundred, six hundred, or one thousand, might have been fixed upon; but mathematicians, in most countries, have fixed upon three hundred and sixty as the number of degrees or divisions in a circle; because, in the first place, it was formerly supposed to be about the number of days in a

* The equator is a great circle of the earth, equally distant from the north and south poles, and divides the globe into two equal parts called the northern and southern hemispheres. From this circle the latitudes of places are counted, either northward or southward. It is represented by the line E Q, in fig. 31.

year, and in the next place, because it is a number that may be divided into halves, quarters, and eighths, without fractions. Now, in order to obtain the dimensions of the earth, it was only necessary that one degree on its surface should be accurately measured in order to obtain the whole circumference. To accomplish this, we must draw a meridian line—that is, a line that runs directly north and south, at any place we make choice of for the first station, and find the latitude or height of the pole at that particular place. We must then prolong the meridian line, either northwards, till we come to a place where the latitude is exactly one degree more—or southwards, till it is one degree less than at the first station. We must then measure the distance between these two places, in miles, leagues, yards, or any other known measures; and then we obtain the number of miles, etc., contained in one degree, or the three hundred and sixtieth part of the earth's circumference; and the number of miles, etc., contained in one degree, being multiplied by three hundred and sixty, gives the whole circumference of the earth. And when the circumference is obtained, the diameter may be found by the rule given in the preceding note, (p. 78.) And when the circumference and diameter are known, the number of square miles on its surface, and the number of cubical miles in its solidity may be obtained by an easy calculation. But although one degree accurately measured would determine the dimensions of the earth, yet more accuracy is obtained by measuring three, five, eight, or ten degrees, as has been done by several European nations.

On the general principle now stated, Mr. Richard Norwood, in the year 1635, attempted to find the circumference of the earth by measuring a meridian line between London and York. He took the sun's altitude when it was in the summer solstice, both at London and York, with a sextant of eight feet radius, and by that means found the difference of latitude between these two cities to be two degrees and twenty-eight minutes. He then measured their distance, in as exact a manner as possible; and having taken into the account all the turnings and windings of the road, with the ascents and descents, he reduced it to an arc of the meridian, and found it to contain 12,849 chains; and this distance being compared with the difference of latitude, gave 5,209 chains, or 367,200 English feet to a degree, which is equal to sixty-nine and a half miles and fourteen poles, and which was considered as a near approximation to the truth, according to which the circumference of the earth would be about 25,035 miles. Since

his time, various admeasurements have been made of different parts of the earth's surface, from which its extent has been still more accurately ascertained. The French have measured a meridian line extending from Dunkirk to Formentara, an island in the Mediterranean, an extent of about eight degrees; and a trigonometrical survey, for the same purpose, under the direction of the British government, has lately been extended over Great Britain. From all the admeasurements hitherto made, it appears that, on an average, a degree of the meridian may be reckoned at sixty-nine and one-fifth English miles; which makes the circumference of the globe 24,912 miles. It may just be noticed farther on this point, that, as the earth is not an exact sphere, but a spheroid, a degree of latitude must measure more in the polar regions than near the equator. From actual measurements, it has been found that a degree of the meridian in Lapland, measures six and a half English furlongs more than a degree at the equator.

(2.)—*Proofs of the annual motion of the Earth.*

We have formerly demonstrated the diurnal rotation of the earth which causes the appearance of the rising and setting of the sun, moon, and stars. We now proceed to state very briefly some of those considerations or arguments by which it is proved that the earth revolves round the sun, as the centre of the system, once every year.

In the first place, there are certain general considerations that render it highly probable, if not certain, that the earth must have a motion round the sun. If we admit the annual motion of the earth, then all the phenomena of the heavens, and the apparent irregularities of the planetary motions are completely accounted for, and the whole system presents a scene of unity, harmony, and order, worthy of the perfections and the plans of Him who is "the only wise God,"—who "hath established the world by his wisdom, and hath stretched out the heavens by his understanding." Whereas if the earth be supposed at rest in the centre of the system, the order and harmony of the solar system appears completely destroyed, the motions of the planets present an inextricable maze, their phenomena cannot be accounted for on any rational principles, and no evidence of wisdom can be traced in the arrangements of the system to which they belong. Again, the sun is the fountain of light and heat for irradiating and cheering all the planets and other moving bodies of the system, and therefore it is necessary that this luminous orb should be placed in the centre, from which position alone its

rays can be distributed in proper proportions to all the worlds which revolve around it. Were the earth at rest in the centre of the system, and the sun and the planets revolving around it, as was formerly supposed, the planets would be at certain times at very different distances from the sun; and consequently, in one part of their orbits, they would be scorched with superabundant heat, and in another part frozen with insufferable cold. But from the centre of the system the emanations of light and heat can be equally distributed to all the planets, whether primary or secondary; and the whole presents to view a system of harmony and order.

The following summary of arguments on this point—did our limits permit us to explain and illustrate them—would appear demonstrative to every one who is acquainted with the subject. 1. The planets Mercury and Venus are observed to have two conjunctions with the sun, but are never in opposition to that luminary, that is, they are never seen in the east, or opposite part of the heavens, when the sun has just set in the west. Now this circumstance could not possibly happen, unless the orbits of these planets lay within the orbit of the earth. If they revolved around the earth as a centre, as the ancients supposed, they might frequently be seen in opposition to the sun. 2. The greatest elongation, or distance, of Mercury from the sun is twenty-nine degrees; and the greatest elongation of Venus, or the distance to which it ever recedes from the sun, is forty-eight degrees, which correspond exactly with the distances assigned them in the system; but if they moved round the earth as a centre, they would sometimes be seen one hundred and eighty degrees from the sun,—a circumstance which was never observed either in ancient or modern times. 3. The planets, Mars, Jupiter, and Saturn, and all the other superior planets, have each their conjunctions with the sun, and oppositions to him, which could not be unless their orbits were exterior to the orbit of the earth. 4. In the arrangement of the planets—according to the system which places the sun in the centre—they will all be sometimes much nearer the earth than at other times; and, consequently, their brightness and apparent diameters will be proportionally greater at one period than at another, which corresponds with every day's observations. But according to the system which places the earth in the centre, their apparent magnitudes should always be the same, which is contrary to fact; the planet Mars, for instance, being in one part of its course, five times nearer the earth than in another, and consequently appearing twenty-five times larger

in surface. 5. All the planets, in their movements through the heavens, are seen sometimes to move toward the east, sometimes toward the west; and at certain points of their orbits, they appear fixed for some time in the same position; all which diversities of apparent motion are the necessary results of the earth's annual motion, and are completely accounted for, when the sun is considered as the centre of the system, and the earth as revolving between the orbits of Mars and Venus. But they are altogether inexplicable, on the supposition that the earth is at rest in the centre of the system. 6. When the planets Mercury and Venus are viewed through good telescopes, they are found to assume different phases, in different parts of their orbits, sometimes appearing gibbous, sometimes like a half-moon, and at other times like a crescent, or a full enlightened hemisphere—as formerly explained; which could never happen, if they revolved round the earth as their centre, and if the earth were not placed in an orbit exterior to that of Venus. But such phases are the necessary result of this position of the earth in the solar system. 7. The law discovered by Kepler, that "the squares of the periodic times of the revolutions of the planets are in proportion to the cubes of their mean distances from the sun," is a law which is established on the most accurate observations, and by which all the planets both primary and secondary are regulated. For example, Venus revolves round the sun in 224 days, and the earth in 365, and the mean distance of the earth from the sun is ninety-five millions of miles. Hence, as the square of 365=133,225, is to the square of 224=50,176, so is the cube of 95,000,000=857,375,000,000,000,000,000,000 to a fourth number, which is the cube of the mean distance of Venus from the sun. And if the cube root of this number be found, it will give about sixty-eight millions of miles for her real mean distance. But this law, which applies to all the heavenly bodies without exception, is completely set aside and destroyed, were the sun and planets to be considered as moving round the earth as the centre of their motions. In short, were we to suppose the earth at rest in the centre of the planetary system, the motions of all the planets would present a scene of inextricable confusion—a scene of such disorder and confusion, as would puzzle not only man, but the most intelligent archangel to account for, and to explain in consistency with the perfections of a Being of infinite wisdom and intelligence.*

* Those who would wish to see a full illustration of the above arguments are referred to "Celestial Scenery, or the Wonders of the Planetary

The most complete and sensible demonstration of the annual motion of the earth is furnished by Dr. Bradley's discovery of "the aberration of the light of the fixed stars." In endeavouring to determine the annual parallax of the stars, he discovered that they are not motionless, but that, during the time the earth takes to traverse its orbit, such of them as are in a plane perpendicular to this orbit, appear to describe circles. This is the phenomenon called "the aberration of light," which is found to be the motion of light combined with the progressive motion of the earth in its orbit, which causes the stars to be seen in a different position from what they would be if the eye were at rest. But as the explanation of this phenomenon would require some minute details, and several figures for its illustration, and as it might not be understood by general readers, we will defer in the mean time from entering upon any further statements. We may just remark, that the fact of the aberration of the stars exhibits the motion of the earth to our senses as clearly as if, from a fixed point in the heavens, we actually beheld it pursuing its course through the ethereal regions.

It is of importance that we acquire clear and convincing views on this subject, in order that we may entertain correct and honourable conceptions of the perfections of the Creator, and of the wisdom and intelligence displayed in the arrangements of his works. For, in all cases, we judge of the character and perfections of the designer and workman from the qualities and perfections which appear in their works. If we view the works of the Almighty through a distorted medium, we shall be apt to entertain incorrect and distorted views of the attributes of Him who designed and formed them. If we view the earth as at rest in the centre of creation, and the sun, moon, planets, comets, and stars—in other words, the whole universe—revolving around us every day, with motions so rapid as to exceed all calculation and comprehension; or if we suppose the planets moving backwards and forwards without any order, and presenting in their motions a series of looped curves and mazes without any marks of design, and exhibiting a scene of inextricable confusion; we should scarcely be led to entertain high and honourable conceptions of the wisdom of Him who formed such arrangements; for the marks of Divine intelligence, on such suppositions, would nowhere appear. Whereas, in the true system of the uni-

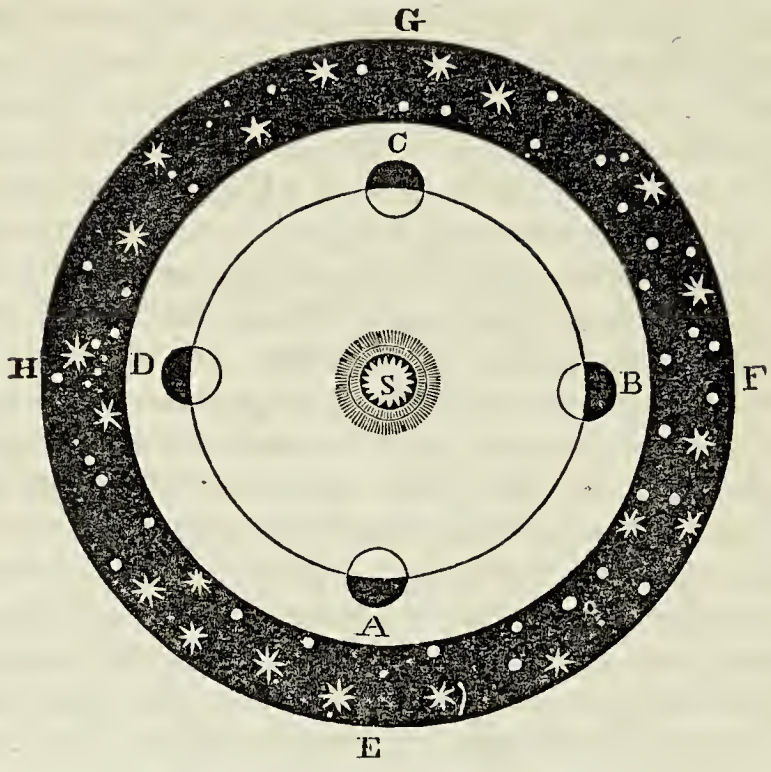
System Displayed;" [Vol. 7. Uniform Edition of Dick's Works,] where these and several other arguments are illustrated in minute detail, and by reference to engravings.

verse which science has laid open, the marks of wisdom and intelligence, harmony and design, are everywhere apparent, and present a scene of operation worthy of the perfections of Him who "established the world by his wisdom," and whose "understanding is infinite." Hence the necessity of acquiring correct views of the works of creation and providence, and of the arrangements which exist in reference to our world, and to the universe around us; for upon such views our conceptions of the great object of our adoration will, in a great measure, depend. When, therefore, we obey the Divine command and "lift up our eyes on high, and behold the wonders of Almighty Power," and "stand still and consider the wonderful works of God," we are to contemplate them, not through the mists of ignorance, or vulgar prejudice, nor with the vacant stare of a savage; but with the eye of a Christian philosopher, and through the light which modern science has diffused over the wonders of creation; and the more we contemplate them in this light, the more clear and expansive will our conceptions be of the attributes of the "high and lofty One who inhabiteth eternity," and who presides over all the movements of the universe.

(3.)—*Phenomena arising from the annual motion of the earth.*

In the first place, if the earth revolve around the sun once every year, it is evident that the sun will appear to make a revolution round the heavens in the same period. In fig. 32, let S represent the sun at rest in the centre, and A B C D the earth in four positions; and let us suppose the earth to move in the order of the letters A B C D; it is evident that when the earth is at A, the sun will appear in that part of the heavens where the stars at G are situate. When the earth has moved to B, the sun will appear to have moved to the stars opposite H; and in like manner, when the earth has moved to C, the sun will appear opposite to E; and when it has moved to D, the sun will appear at F; after which it will again appear at G, when the earth has moved to A. And as the earth revolves around the sun in the orbit A B C D, so the sun will appear to a spectator on the earth to describe the circle in the heavens E F G H. Hence it is that we see the sun gradually proceeding in his course round the concave of the sky from west to east at the rate of nearly one degree every day, through the twelve signs or constellations of the zodiac; and at the end of a year, he returns to the same point from which he set out. Hence also it follows, that if the plane of the earth's orbit be imagined to

Figure 32.



be extended to the heavens, it would cut the starry firmament in that very circle in which a spectator in the sun would see the earth revolve every year, while an inhabitant of the earth would observe the sun to go through the same circle in the same space of time. This circle is called the Ecliptic, or the apparent path of the sun through the heavens. And, although the path of the sun, and the particular stars he is passing along, cannot be seen in the daytime, yet, from observing the stars that are directly opposite to him at night, we can tell at any time what particular stars the sun is passing along in every part of his course.

The inhabitants of all the other planets will perceive similar motions in the sun as we observed, but performed in different periods of time, according to the times of their annual revolutions. For example, an inhabitant of Jupiter would see the sun apparently revolving around him, describing a circle in the heavens in the space of twelve years. This circle would not be exactly the same as our ecliptic, because the orbit of this planet is somewhat inclined to the orbit of the earth; but it would pass very near it. In the course of one of our years the sun, from Jupiter, would appear to pass through only a twelfth part of the circumference of the heavens. The sun from Saturn will appear to move in another circle in twenty-nine years and a half; and a spectator in Venus will see the sun moving in a circle different from all these, with greater apparent rapidity, in the space of seven

and a half months. All these apparent motions of the sun arise from the real motions of the respective planets.

In the next place, the annual revolution of the earth shows the reason why we behold one set of stars in our firmament at one season of the year, and another set of stars at a different season. For example, in our latitude, the stars, and constellations which are seen during the winter months, in the south, are altogether different from those which are seen in summer; and those stars which surround the pole in the north, and which never set, if they are below the pole in winter, they will be seen as far above the pole in summer. At the equator, where all the stars rise and set, the stars which appear in the middle of winter are all completely different from those which are seen at the same hour in the middle of summer. This is easily explained by the preceding diagram, (fig. 32,) in which the earth, in four situations in its orbit, appears half enlightened and half in the dark, representing day and night. When it is at A, the sun will appear at noon at G, and obscure all the stars in the hemisphere F G H; whereas at midnight the point of the heavens E will be in the meridian, and all the stars in the other hemisphere F E H will be visible. Three months afterwards, when the earth comes to the situation B, the sun at noon will be seen at H, and all the heavens G H E will be day, illuminated by the sun; and over all the other half E F G, the stars will shine at night. Consequently, the stars in the quarter F G will now be visible, which in the former position were obscured by the sun, and those in the quarter H E, formerly visible, will become obscured by daylight. In like manner, when the earth is at C, the heavens H E F will be day, and F G H night, where all the stars which were obscured, when the earth was at A, will now be visible. And, lastly, when the earth is at D, the stars and constellations in the hemisphere E F G, will be obscured by the light of the sun, and those on G H E will be visible during the night. Hence, every one who is accustomed to look at the heavens will have observed that the bright constellation Orion, the brilliant star Sirius, which follows it, and the Pleiades, or seven stars, which are visible in the southern part of the firmament during winter and the approach of spring, are never seen during the summer months, because the sun is then illuminating that portion of the heavens where they are situate; but they may be seen in the daytime by means of equatorial telescopes.

(4.)—*On the destination of the earth, or the final cause of its creation.*

In the creation of the material universe, the Creator must have had some grand designs in view, besides the mere formation of immense globes of matter and setting them in motion, and arranging them into systems. In so far as we are able to penetrate, it appears demonstrable that matter exists chiefly, if not solely, for the sake of sentient and intellectual beings. This evidently appears to have been the chief design for which our globe was created; and we have the strongest reason to conclude that this was the main end for which all the other planetary globes belonging to the solar system and to other systems, were brought into existence. Hence it is declared in the sacred oracles, when reference is made to the formation of our globe, "God formed the earth and made it;—he created it not in vain; he formed it to be inhabited;" which evidently implies, that to have created it without the design of its being inhabited, would have been an instance of folly inconsistent with the perfections of Him whose wisdom and intelligence are infinite; and the same reasoning will apply to all the other planets, which appear to be furnished with every accommodation adapted to sensitive and intellectual enjoyment.

In peopling the earth and other globes with inhabitants, the Creator evidently intended to give a display of his perfections to beings capable of contemplating it, and to promote their sensitive and mental enjoyment. The happiness of his creatures must have been one grand design which the Creator had in view, when he breathed into them the breath of life, and made them rational and immortal beings. Accordingly, we find that when man was at first placed upon this globe, every thing that was beautiful to the eye and the imagination, and pleasant to the taste, was prepared for his accommodation and comfort. The waters were separated from the dry land—the earth was adorned with verdure—rivers and refreshing streams flowed around him to increase his pleasures—trees, and plants, and flowers of every form and hue diversified and embellished the landscape. Light was formed, and celestial luminaries appointed to diffuse its radiance—a canopy was thrown around his habitation adorned with thousands of shining orbs, to elevate his contemplations to other provinces of his Creator's dominions—every plant and tree yielding delicious fruit was provided to gratify his

taste, and afford him sustenance; and all the inferior ranks of sensitive existence were placed under his dominion. One chief design of the Almighty, in these arrangements, was to show man his dependence, to make him an adorer, and a being capable of knowing and honouring his Creator and bountiful Benefactor. He gave him a law which implied supreme love to his Maker, and obedience to his will; and as an external sign of his obedience he said to him, "Behold all the trees of the garden in which I have placed thee; of every one of them thou mayest freely eat—only thou shalt forbear eating the fruit of the tree of knowledge." This reserve—which has been so frequently objected to—did in reality constitute the chief glory of man. None of the inferior animals knew their origin or their Benefactor, they could give no testimony of gratitude, nor could they exhibit any shadow of religion. Man alone was elevated to a rank, and endowed with faculties so as to know to whom he is indebted for all his enjoyments—and he alone was taught to express his gratitude to the Giver of all good! This constituted the true glory of man, and his superiority over all the other tribes of sensitive existence. It was a great and honourable prerogative conferred upon him to be able to obey his Benefactor, and to adore the hand which had loaded him with blessings: and therefore it was proper that a visible emblem of his obedience, or the contrary, should be continually before his eyes. The supreme Creator stood in no need either of the fruit of a certain tree, or of the opinions, or sentiments of man respecting it. But it was fit that man should make an express profession of his gratitude and veneration: and therefore the sole exception which God made in his first transaction with man, was at once the memorial of his gratitude, and the public expression of his piety and submission to the Divine will.

But we know that man did not remain in his primeval state of innocence and happiness, but by his disobedience "brought death into the world, and all our wo." For proof of this position, we have no need to enter into long trains of reasoning, or even to appeal to the records of revelation. The fact of man's fall and disobedience is written on the whole history of our world from the earliest ages to the present time. For what does the history of all nations chiefly record? It presents to our view little else than wars and commotions, contentions, and animosities, and "garments rolled in blood." One nation rising up against another, carrying fire and sword,

and all the engines of destruction into a peaceful territory—laying waste provinces, burning cities, turning fruitful fields into a wilderness, and slaughtering, with diabolical fury, thousands and tens of thousands of their fellow-men. This has been one of the chief employments of all the tribes and nations that have ever dwelt on the face of the earth; and this fact, of itself, is a sufficient proof that man is no longer in his primeval condition of paradisaical innocence and rectitude, but is fallen from his high estate, and his glory turned into shame. We trust there is not another instance of creatures endowed with rational faculties, and formed after the Divine image, acting in this way, to be found among all the other worlds of the universe. And were we not accustomed to witness such infernal passions and atrocities, and to behold men glorying in that which is their shame, we should be filled with utter astonishment and wonder that such horrible actions should be perpetrated on each other by brethren of the same family, children of the same Father, and beings destined to an immortal existence.

But the benevolent Father of all did not intend that this moral derangement should be universal and perpetual. As soon as man had fallen from his allegiance to his Maker he displayed his character as a God of mercy, and ready to forgive. He declared that the seed of the woman should bruise the head of the serpent—that an illustrious Messenger, invested with Divine power and authority, should be sent into the world at a proper time, to repair the ruins of the fall; "to finish transgression, and to make an end of sins;"—to bear the sins of many, and make "intercession for the transgressors." Preparatory to the advent of this Divine Messenger, certain families were selected in which the knowledge of the true God might be preserved—a certain nation, before whom astonishing miracles had been displayed, was chosen as the depository of Divine revelations—a ceremonial worship was instituted, prefigurative of the events and blessings of Messiah's reign; prophets were raised up to announce the coming of the Great Deliverer, and the glorious results of his administration—the events of Divine Providence towards the nations were overruled and directed in such a manner, as to bring about the advent of the promised Messiah in all the circumstances which prophets foretold, and which God had appointed; and, when the predicted period had arrived, a retinue of celestial messengers was despatched from heaven to earth to announce the appearance of "the Son of the Highest," of the increase of whose government there should be no end,

and to proclaim "glory to God in the highest, and on earth peace, good-will towards men." And when this Deliverer appeared on the public theatre of the world, he exhibited the most convincing proofs of his Divine mission by the most astonishing and beneficent miracles, displaying his power over the laws and the elements of nature—the spirits of darkness, and the disorders of the human frame—"healing all manner of sickness and disease;" causing the deaf to hear, the blind to see, the lame to walk, and the tongue of the dumb to sing—raising the dead to life, and recalling the departed spirit from the invisible world. And, at length, when the great Sacrifice for the sins of men was about to be offered, a series of the most august and striking supernatural events attended its accomplishment—the sun was clad in black, the heavens were arrayed in sackcloth, darkness for three hours covered the whole land, the veil of the Jewish temple was rent in twain from the top to the bottom, the earth trembled and shook, the rocks rent asunder, the graves were opened, and many bodies of saints that slept in the tombs arose to life. On the third morning after this solemn scene, the "Prince of Peace" arose victorious from the grave, showed himself openly to competent witnesses of his resurrection; and afterwards, rising above the confines of this earthly ball, winged his flight on a resplendent cloud, attended by myriads of angels, through distant regions which "eye hath not seen," and entered into heaven itself, there to "appear in the presence of God for us."

In consequence of these astonishing and benevolent arrangements, all men, everywhere, are now commanded to repent, with the full assurance that they shall obtain pardon, peace, and reconciliation, and every blessing requisite for their happiness in the present world and in the life to come. For thus runs the message of the Most High to all the children of men: "God so loved the world, that he gave his only begotten Son, that whosoever believeth in him should not perish, but have everlasting life." "Whom God hath set forth to be a propitiation through faith in his blood, to declare his righteousness for the remission of sins." "This is the record, that God hath given to us eternal life, and this life is in his Son." These announcements are made to all the inhabitants of this world, however vile, and however atrocious the deeds they may have committed—to the ferocious warrior that has slaughtered thousands, and to those who have long wallowed in the mire of depravity and licentiousness, as well as to those who have manifested some external decency of conduct. For He who is exalted as a Prince and a Saviour "is able also to

save them to the uttermost that come unto God by him." And if we believe the record of God, and rest upon it as the declaration of a faithful Creator, we shall endeavour "to abound in all the fruits of righteousness"—to cultivate love towards God and towards man—"to add to our faith, virtue, knowledge, temperance, patience, brotherly kindness, and charity," and every other Christian disposition and virtue which will tend to prepare us for the intercourses and employments of that higher sphere of existence where all is peace, and harmony, and love.

One reason why the benevolent arrangements which have been made for the happiness of man have been so long kept hid from the greater part of the world, and moral evil has been permitted to abound, doubtless is, that an extensive and impressive display might be given of the dismal and miserable consequences which necessarily flow from refusing allegiance to the Most High, and from a violation of his laws—to serve as a warning not only to the inhabitants of our globe, but to the inhabitants of other worlds, of the necessity of submitting to the will of the Supreme, and of the inevitable disastrous effects which flow from the prevalence of moral evil. For if the fundamental laws of heaven—love to God and to man—were to be reversed, or universally violated, misery would pervade the whole moral universe, although it consisted of millions of worlds; and happiness could never be enjoyed by any rank of intelligent existence. But, however dismal a scene may have been presented to view, in the ages that are past, we are assured that a period is approaching—foretold by inspired prophets—when the world shall be regenerated, when "wars shall cease even to the end of the earth;" when violence and oppression and all unrighteousness shall be undermined and destroyed; when "the kingdoms of this world shall become the kingdoms of our Lord, and of his Christ;" when "every one shall sit under his vine and fig-tree," without the least fear of annoyance; when "the earth shall be full of the knowledge of the Lord, as the waters cover the sea," and "the Lord God will cause righteousness and praise to spring forth before all the nations." Then the antipathies of nations shall be destroyed; "the earth shall yield her increase;" its desolate wastes shall be cultivated, and its ruins restored, and all people "shall dwell in a peaceable habitation and in sure dwellings, and in quiet resting-places." And when the purposes of Divine Providence shall have been fulfilled in regard to the present state of our globe, its constitution shall be changed, its elementary parts dissolved; "and

"new heavens and a new earth" shall arise wherein righteousness shall for ever dwell. Such is the destination of our world, and such are the arrangements which its Creator has made in reference to its inhabitants.

Some readers may, perhaps, be disposed to say, "What has all this theological dissertation to do with astronomy? we do not see that it has any connection with a description of the solar system." On this point we beg leave to differ from such objectors. What is the material universe, when separated from its reference to the Creator, and its relation to intelligent beings? A mere machine, which displays nothing but uncontrollable power acting at random, without the least trace of wisdom, benevolence, or rectitude. To view the planetary system, or other systems, as consisting merely of a number of large globes, wheeling round their axes, and round their suns, in certain periods of time, is to overlook some of the grandest and most interesting objects of astronomy. To suppose all the orbs of heaven to be self-existent and self-moving is absurdity and atheism; and to suppose the Creator to have formed them merely as so many august and splendid pieces of machinery, without any relation to intellectual natures, is inconsistent with every idea we ought to form of the attributes of the Divinity. The relation of the material system to intellectual beings ought, therefore, to be connected with astronomical investigations. We know not, indeed, the physical and moral characteristics of the inhabitants of Venus, Jupiter, or other planets; but we know, for certain, that if they be in a state of primeval innocence and happiness, they obey the two grand principles of the law prescribed to the inhabitants of our world—"Love to their Creator, and love to one another," without the observance of which precepts, true happiness cannot be enjoyed in any world in the universe, and the whole material creation would be nothing else than a boundless Pandemonium. We know that these precepts have been generally violated in our world; and hence the wars, devastations, insurrections, systems of oppression and iniquity, and other evils, which have produced so much misery and wretchedness among the population of our globe. And shall it be considered as improper and unphilosophical, that, in describing the material fabric of the world, those arrangements which the Almighty has formed for the regeneration of society, and the happiness of the human race, should be occasionally adverted to and detailed? We must demur to such a sentiment. Philosophy has been too long dissevered from its connection with religion—to which it ought

ever to be allied; and it is now high time that every department of human knowledge should be studied in connection with the moral arrangements of the Almighty, the renovation of the world, and the eternal destiny of man. The sciences, when disjoined from such connections, lose the greater part of their value, and can be considered as useful only in reference to the concerns of this world, and the transitory duration of the life of man. Whereas, when studied with right views, and in all their legitimate connections and relations, they bear an intimate relation to the Divinity, to the progress and expansion of the human mind to other worlds, and to the scenes and employments of an immortal existence.

In reference to the earth, we shall now only state the following circumstances: The number of inhabitants which people the earth at one time is estimated at eight hundred millions—of these, five hundred millions are reckoned to Asia; fifty-eight millions to Africa; forty-two millions to America; and two hundred millions to Europe. Of these assemblages of human beings, twenty-five millions die every year, sixty-eight thousand every day, two thousand eight hundred and fifty every hour, and forty-seven every minute; so that at almost every pulse that beats within us, an immortal being is passing from time into eternity, from this visible and material world to another scene of existence—a solemn and important consideration to every one of us who must shortly follow, in our turn, the generations that have gone before us. If we reckon thirty-two years as the average period for a generation, as has been generally done—at the end of which period the whole human race is renewed, with a few exceptions; it will follow, that one hundred and forty-six thousand two hundred millions of human beings have existed on our globe, since its present arrangement commenced, reckoning 5849 years from the formation of Adam to the present time. But if we make our estimate according to the Samaritan and the Septuagint chronology, 7256 years are to be reckoned from Adam to the present time; and consequently, if mankind had never died, there would have been, at present, on the surface of the globe, 182,800,000,000: that is, one hundred and eighty-two thousand eight hundred millions of human beings. Whether the earth would have furnished subsistence for such a population is left to Malthusians and political economists to determine. But it appears, in point of fact, that the Creator never intended that such a number of the human species should remain on the earth at one time, in its present state; though it might easily

be shown, that, were all the habitable parts of the globe properly cultivated, it would support at least sixteen thousand millions of human beings, or twenty times the number that now exist on its surface, while each family would have an estate of twelve acres of land for its support. But the inferior tribes of animals are far more numerous than the amount of all the human inhabitants that have ever dwelt on the earth, from Adam to the last new-born child. At a rude calculation, the inferior tribes connected with the air, the waters, and the dry land, at one time, cannot amount to less than thirty billions of living beings; which is 164 times the number of all the human beings that have ever appeared on the earth. As one instance out of many of the immense numbers of certain species of animals, we may mention what Mr. Wilson states, in his "American Ornithology," that a single flock of the migratory pigeon of the United States was found to be about a mile in breadth and 240 miles in length—having occupied four hours in passing across the country; which flock, by a moderate calculation, was estimated to contain two thousand two hundred and thirty millions, which is nearly three times the human population of the globe.

We may just farther make the following statements in reference to the earth. In its course round the sun, it moves in an elliptical orbit, the longer diameter of which is 3,236,000 miles greater than the shorter, and consequently it is nearer the sun at one season of the year than at another. The time of its annual revolution is 365 days, 5 hours, 48 minutes, 49 seconds, which is called the tropical year; but the time it takes in moving from a fixed star till it returns to it again is 365 days, 6 hours, 9 minutes, 12 seconds,—which is called its sidereal year. With regard to the density of the earth, it is found to be about five times denser than water; so that could we suppose five globes as large as the earth composed of water, suspended at one end of an immense balance, and the earth at the other, they would nearly counterpoise each other.

SEC. V.—ON THE MOON.

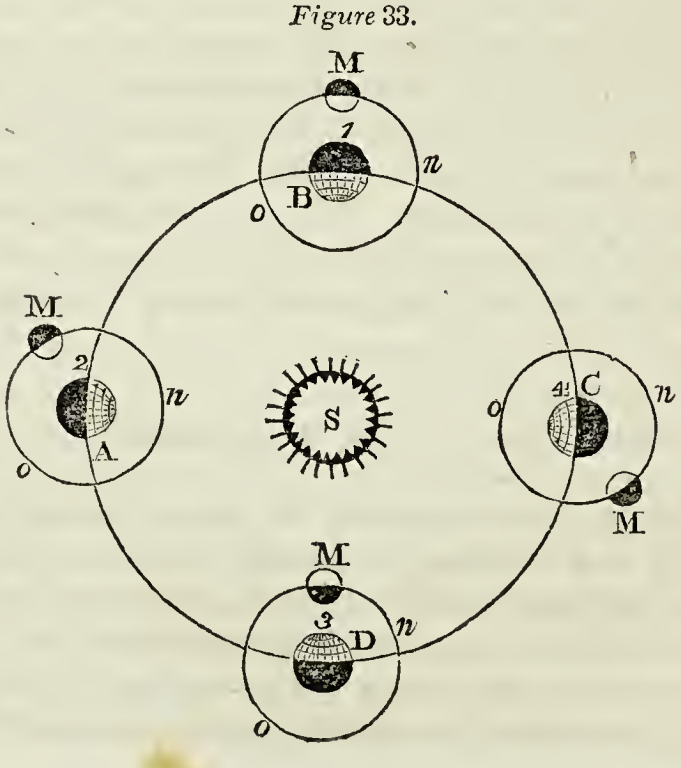
The moon is the nearest of all the celestial bodies to the earth, and is its constant attendant during its revolution round the sun. It belongs to that class of bodies called secondary planets, or satellites. A primary planet is one which revolves around the sun as its centre: a secondary planet is a body which revolves around a primary planet as its centre of mo-

tion, and is at the same time carried along with its primary around the sun.

Motions of the Moon.—The moon has an apparent motion round our globe every day, somewhat similar to that of the sun. She rises in an easterly direction, and, after a certain number of hours, sets in the western quarter of the heavens; this motion is not real, but only apparent, and is caused by the diurnal motion of our globe from west to east. The real motions of the moon are as follows:—In the course of 27 days, 7 hours, and 43 minutes, the moon makes a progress through the ecliptic, or round the whole heavens, from west to east, and returns to the same stars from which she set out. This is called her tropical revolution. The period from one new moon to another, or from one conjunction with the sun to another—which is 29 days, 12 hours, 44 minutes, and 2 seconds, is called her synodic revolution. The reason why these periods are different is this: at new moon, the sun and moon are in the same part of the heavens: but by the time the moon has returned to that point—namely, 27 days, 7 hours, 43 minutes—the sun has proceeded, in his apparent course through the heavens, twenty-seven degrees farther to the east, and is still going on, and the moon has to overtake him before she can be again in that position which is called new moon.

Fig. 33 exhibits some of the motions of the moon in relation to the earth and the sun. The small circle in the centre, S, represents the sun; the circle A B C D, the earth's orbit,

Figure 33.



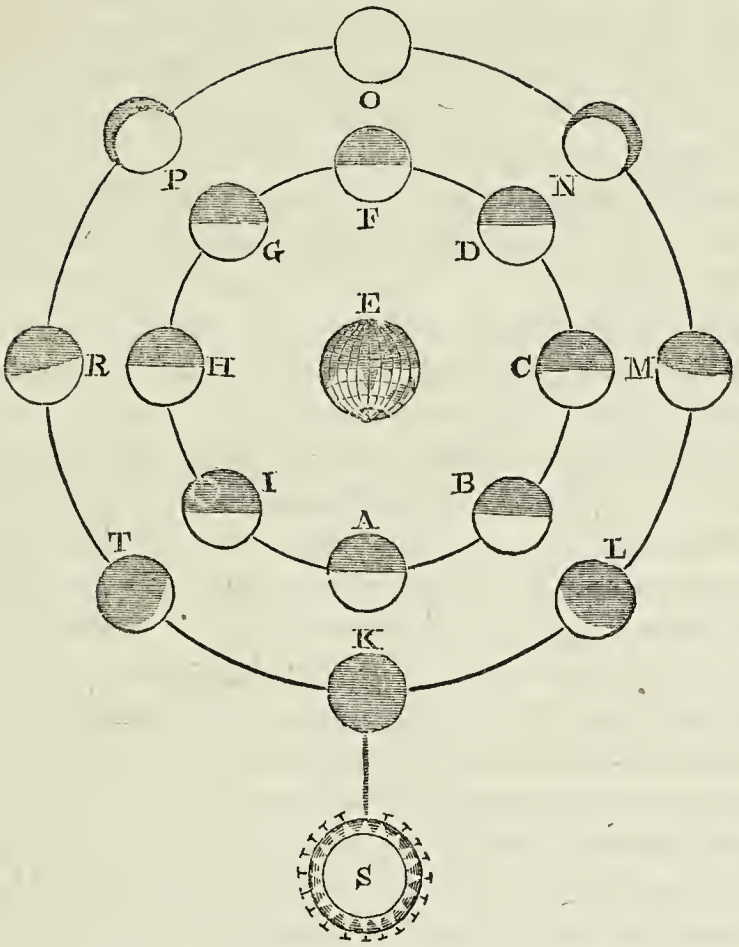
and the earth in four different positions. The smaller circle M *n o*, represents the orbit of the moon in its course round the earth. Around this orbit she moves, in a period somewhat less than a month, at the rate of 2300 miles an hour. But while she is thus carried, monthly, around the earth, she is also carried forward along with the earth, in its revolution round the sun. For example, while the earth has moved from B to A, the moon has made more than three revolutions round the earth, and at the same time has moved, along with the earth, nearly one hundred and fifty millions of miles, or the fourth part of the earth's annual circuit; so that the moon's motion through space is much more rapid than that stated above, and cannot be estimated at less than 70,000 miles an hour. When the earth is at B, in the position marked I, and the moon at M, the enlightened side of the moon is turned to the dark side of the earth, and the moon is in the position we call full moon, the whole of its enlightened surface being then turned towards the earth. When the earth is at D, and the moon in the position marked 3, the dark side of the moon is turned toward the earth, and she is consequently invisible. This is the position of new moon. In the manner now described, does the moon revolve round the earth, and is carried along with the earth round the sun, from one year and one century to another; and has done so ever since she was appointed to give light to the earth, and "to rule the night." And since she is acted upon by two forces—the attraction of the earth, and the attraction of the sun, which sometimes act in opposite directions—her motions are very irregular; which renders it somewhat difficult and tedious to calculate her precise position in the heavens at any particular moment of time.

Phases and general appearances of the moon.—The sun always enlightens one-half of the moon; and sometimes the whole of this enlightened side is turned towards the earth, when she appears a round luminous orb: but this happens only in one point of her orbit. At all other parts of her course, only a portion of her enlightened hemisphere is seen from the earth; and in one particular position in her orbit, her enlightened side is altogether invisible. When she is at the change, or the period of new moon, she is invisible; both because she is in the same part of the heavens as the sun, and because the whole of her dark hemisphere is then turned to the earth. After this it is generally two days, or more, before any part of her enlightened surface is visible. About the third day after the change, she is seen in the western

sky, at no great distance from the point at which the sun set, and then appears under the form of a slender crescent, with its horns pointing towards the east. Next evening, about the same hour, she will have moved about thirteen degrees farther to the east, and her crescent will appear to have increased somewhat in breadth. Every succeeding night she will appear to have moved still farther to the east, while her crescent is still increasing in breadth and luminosity, till about the eighth day from the change, when she appears in the form of a half-moon. She is then about ninety degrees from the sun. After this period, still proceeding eastward, she assumes a gibbous phase, till she arrive at the period of full moon, when her whole enlightened hemisphere is turned toward us; which happens on the fifteenth day after the time of the new moon, when she is in opposition to the sun, or one hundred and eighty degrees distant, and rises about the time when the sun sets. On a cloudless night, she then displays to every beholder a delightful and magnificent spectacle, calculated to arrest the attention of every eye, and to inspire the soul with emotions of sublimity. But she does not remain long in her full-orbed lustre; she gradually loses a portion of her brightness, by presenting to us a part of her dark hemisphere. She again appears for a few days in a gibbous phase; afterwards she assumes the appearance of a half-moon, and then that of a crescent, whose horns are now turned towards the west. In this position she is seen only in the mornings before sunrise; and, in a few days afterwards, she is in conjunction with the sun, when her dark side is again turned towards the earth. All these changes are accomplished in twenty-nine days and a half.

These phases are more particularly represented in fig. 34, where S represents the sun, E the earth, and A B C D F G H I the moon in different parts of its circuit round the earth, with its hemisphere turned towards the sun fully enlightened. When the moon is at A, its enlightened side being turned to the sun, its dark side is towards the earth, and were it then visible, it would appear as at K, in the outer circle; but it is never visible in this position, except at the time of an eclipse of the sun, when its body, either in whole, or in part, interposes between us and the sun. This is at the period of new moon. When the moon has moved from A to B, a portion of its enlightened surface is then turned to the earth, and it appears as a crescent, as represented at L; when arrived at C, the one-half of its enlightened hemisphere is turned to the earth, and it appears in the form of a half-moon, as at M;

Figure 34.



when arrived at D, it presents a gibbous phase, as at N; and when arrived at F, it shines in all its splendour as a full moon, as at O. After this period it gradually declines, first to a gibbous phase, as at P; next to a half-moon, as at R; then to a crescent, as at T; after which it arrives at its former position at A, the period of new moon; when it is again invisible.

How the earth appears to the inhabitants of the Moon.—We have now seen the cause why the moon presents so varied appearances to the earth; let us now consider how the earth itself will appear as viewed from the surface of the moon. Could we take a view of the earth from one of the mountains, or plains, of the moon, we should find that it exhibits the same changes, or phases, that the moon does to us, but in a reverse order. For when, at new moon, the dark side of the moon is turned towards us, the whole of the enlightened hemisphere of the earth is then turned towards the moon. And as the hemisphere of our globe is thirteen times larger than that of the moon, it will present in the lunar firmament a shining orb as large as thirteen of our full moons, and will, therefore, diffuse a considerable degree of lustre in the absence of the sun. That the earth shines with a full

enlightened face upon the moon at the period now stated, will appear from the preceding diagram, fig. 34. At A, the moon is in conjunction with the sun as seen from the earth, and its dark side is turned towards us; but it will be perceived that, at that time, the enlightened side of the earth, E, is completely turned towards the moon, so that, while she is invisible to us, our globe appears in its full orbed majesty and brightness to the lunar inhabitants. On the other hand, when the moon is at F, when it is full moon to us, the dark side of the earth, E, is turned towards the moon, and is consequently invisible to the inhabitants of the moon, being then nearly in the same part of the firmament as the sun. When the moon is increasing to us, the earth is diminishing in its illuminated surface to the moon. When the moon is at B in its increase, the earth appears as at P; when she appears as a half-moon as at M, the earth appears a half-moon in the decrease, as at R; and when she increases to a gibbous phase as at N, the earth has decreased to a crescent, as at T; so that the phases of the earth, as seen from the moon, are exactly opposite to those of the moon as seen from the earth.

That the earth actually shines upon the moon, and illuminates its surface as the moon does that of the earth, is proved from the following circumstance. On the second or third day after new moon, when she appears as a slender crescent, we perceive a faint light on the dark part of the moon which is not enlightened by the sun, so that the whole hemisphere of the moon is visible—one part faint, and the other bright. This is perceptible even by the naked eye, but it appears pretty vivid through the telescope when a small power is applied, so that many of the principal spots of the moon may be distinctly perceived. This may be termed the "moonlight of the moon," as the earth is then shining upon its surface with nearly a full-enlightened hemisphere. This light on the dark side of the moon gradually decreases, as the enlightened part of the moon increases, because the enlightened portion of the earth is at the same time diminishing, so that its effect is not much perceived after the period of half-moon. It has been sometimes observed that a brighter reflection proceeds from the moon when the continental parts of the earth are opposite to her than when the Atlantic or the Pacific ocean is in the same position. There is less light reflected from the sea than from the land upon the moon, and therefore it is natural to suppose that when the hemisphere of the earth, which contains Europe, Asia, Africa, and New Holland, is shining upon the moon, a considerably greater

quantity of light will be reflected on her surface than when the Pacific ocean, which covers nearly half our globe, is directly opposite to her. In the course of the diurnal rotation of the earth every part of its surface in succession will be presented to the moon; and therefore it will appear to a lunar inhabitant with different degrees of brilliancy, at different times, arising from the circumstances now stated. (See fig. 31, p. 76.)

The moon always presents the same side to the earth, so that we never see its opposite hemisphere. This circumstance proves that she turns round her axis in the same time she takes to move round the heavens. If the moon had no motion round her axis, we should see both her hemispheres in the course of every revolution she makes round the earth. Whether the other side of the moon be less adapted for reflecting light than that which is next us, or whether it be equally diversified with mountains, caverns, and plains, we have no opportunity of determining; though, reasoning from analogy, we may conclude that the arrangements of nature in that hemisphere are not essentially different from those we perceive in the hemisphere presented to our view.

There is a peculiar appearance which may be noticed, that the earth will present to an inhabitant of the moon, and it is this—that from any particular spot on the lunar surface, the earth will appear in a fixed position in the heavens, without any apparent motion. To those who live in the middle of the hemisphere next the earth, the earth will appear as a large globe in the zenith, or point directly above their heads, sometimes appearing as a half-moon, a crescent, or a full-enlightened hemisphere, and sometimes invisible, but always in the same position. The only motion they will occasionally perceive is the earth's rotation, which they will observe as the different continents, islands, and oceans of our globe present themselves in succession. Those who live near the margin of the moon's hemisphere next the earth, will see the earth near the horizon, and it will never appear from such places in a more elevated position in the heavens. Those who live in intermediate positions will behold the earth at higher or lower elevations, according to their distance from the centre of the hemisphere. All these appearances necessarily result from the circumstance that the moon always presents the same side to the earth, and to account for such phenomena will be apt to puzzle the lunar astronomers. Hence, it necessarily follows that those who live on the opposite hemisphere of the moon will never see the earth nor

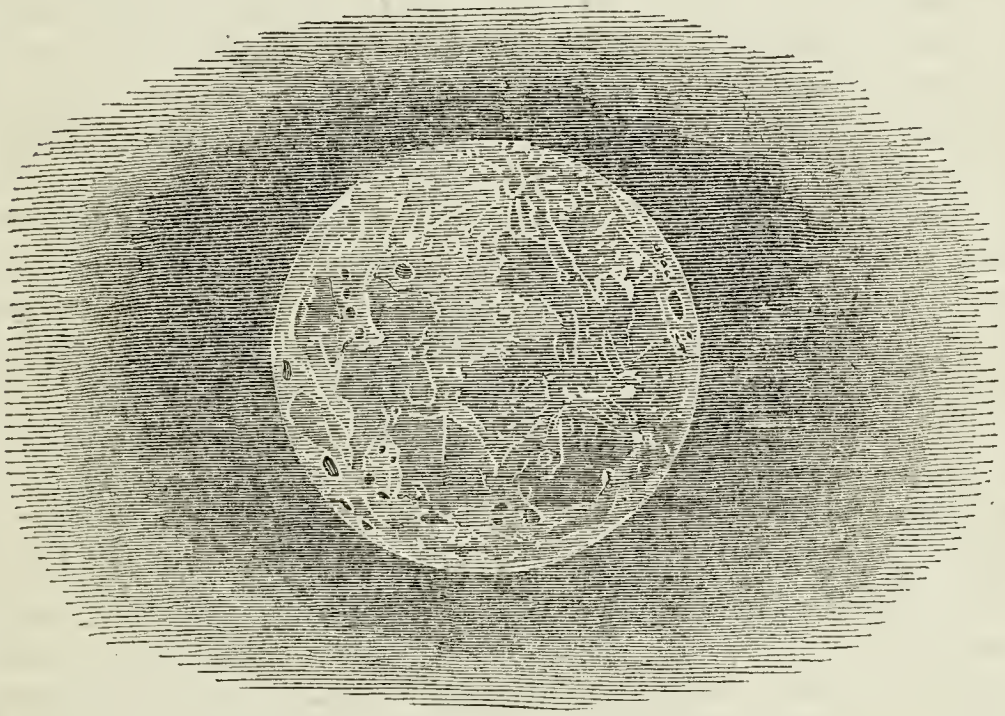
enjoy its light. From the central parts of that hemisphere, an astronomer—who had heard of the remarkable celestial phenomenon to be seen in the other hemisphere—would have to travel more than 1700 miles before he could see the earth emerging from the horizon; and in order to behold it in its full lustre, shining directly from the zenith, he would have to travel 1700 miles farther, or 3400 miles in all. We presume that there are few terrestrial astronomers who would grudge to undertake such a journey were they to behold a resplendent moon hanging in the vault of heaven in another hemisphere, which is altogether invisible in his native country. Sir J. Herschel, in order to explore the starry regions in the southern hemisphere, undertook a voyage to the Cape of Good Hope, where he remained for years, and brought home some interesting pieces of intelligence from the starry regions.

Distance and magnitude of the Moon.—The moon, though the nearest celestial body to the earth, is still at a considerable distance. This distance is reckoned to be, at a medium, about 237,000 miles, or about thirty times the diameter of our globe, which is determined from its horizontal parallax, or the angle formed by a line drawn from the centre, and another line drawn from the surface of the earth. As the moon, however, moves in an elliptical orbit, she is sometimes more than 240,000 miles distant, and sometimes considerably less than 237,000. Small as this distance is, compared with that of the other planets, it would require nearly 500 days, or about sixteen months, for a steam-carriage to move over the interval which separates us from the lunar orb, although it were moving day and night at the rate of twenty miles every hour. Although the apparent size of the moon is equal to that of the sun, yet the difference of their real bulk is very great; for it would require more than sixty-three millions of globes of the size of the moon to form a globe equal in magnitude to that of the sun. The reason why the sun appears so small, when he is in reality so large a globe, is this—that he is removed ninety-five millions of miles from the earth, which is nearly four hundred times farther than the moon. The diameter of the moon is 2180 miles, which is little more than the fourth part of the diameter of our globe, and consequently, in point of solidity, it is only the forty-ninth part of the bulk of the earth. Its surface, however, contains fifteen millions of square miles, or about one-third of the habitable regions of our globe; and were it peopled as densely as England, it would contain a population amounting to four thousand two hundred millions,

which is more than five times the population of the earth. The circumference of the moon is 6848 miles, and, therefore, if a railroad were formed around it, its inhabitants could travel completely round their world in the course of fourteen of our days, at the rate of twenty miles an hour; and the journey could be so arranged that they might enjoy uninterrupted moonlight from the earth in one part of it, and uninterrupted sunlight during the other—an advantage which we can never enjoy in our terrestrial region.

Telescopic appearance of the Moon.—When the moon is viewed with a good telescope, the lunar surface presents a very interesting and diversified appearance. Mountains and plains, caverns and insulated rocks, hills and plains of almost every shape, diversify every portion of the surface of the

Figure 35.



moon. It is evident, almost at first sight, that the moon is diversified with inequalities of surface, and has lofty eminences and deep vales, when we view her surface with a powerful telescope, when she appears in the form of a crescent, or of a half-moon; for then we perceive the boundary between the dark and enlightened side—not a straight line or a regular curve, as it would be if the moon were a smooth surface—but jagged and uneven, somewhat like the edge of a coarse saw. Within the dark portion of the moon, adjacent to this boundary, bright points appear, somewhat like stars, which are evidently the higher tops of the lunar mountains, enlightened by the sun before his rays can reach the valleys, just as we find that in our globe, when the sun is rising, his

beams gild the mountain tops, while the plains and valleys are still in the shade. Shadows of different dimensions, too, are to be seen in various parts of the enlightened portion of the moon, indicating both elevations and depressions.

The mountainous regions of the moon are arranged in a very different form from those of the earth. There are, indeed, some mountain ranges on the lunar orb somewhat resembling our Alps, and Apennines, and Andes; but one of the distinguishing features of the moon consists in hundreds of circular ranges of mountains surrounding plains of the same shape. The following are a few of the characteristic features of the lunar surface. 1. Plains of various extent and peculiarities. Some of these plains are more than one hundred miles in diameter, or in length and breadth. They present a darker and more sombre appearance to the eye than the other parts of the lunar surface, and, in many instances, they contain, here and there, deep cavities. They were formerly considered as seas, or large collections of water, but there appears no evidence that seas, or any large collection of waters, exist on the surface of the moon. Besides these large plains, there are numerous circular plains of a lesser size, of all dimensions, from two or three miles to thirty miles in diameter, surrounded with a circular ridge of mountains, as with a wall or rampart. These are to be found in most regions of the moon, and they form a peculiar feature of her surface altogether different from what obtains on our globe. 2. The moon displays a great variety of mountain scenery. In the first place, there are chains of mountains, which run in a right-lined direction, not altogether unlike those which exist on our globe. The most remarkable range of this kind is that called the Apennines, which traverses a portion of the lunar disk from north-east to south-west, which may be seen to advantage about the time of half-moon, and a day or two afterwards. It rises with a precipitous and craggy front, from a large plain called the *mare imbrium*, extends to a great length, and, in some places, rises to the perpendicular height of four miles. This is most precipitous on the side of the plain, and gradually slopes off with its hundreds of peaks to the opposite declivity, resembling in some degree our Andes and Himalayas. In the next place, there are insulated mountains, or peaks, or mountains in the shape of a sugar-loaf, which rise directly from the plains, and are altogether unconnected with any ridge or group whatever. Some of these are several miles in perpendicular altitude, and their shadows thrown opposite to the sun are as distinctly seen through the telescope as the shadow of a gnomon on a

sun-dial. They bear a certain resemblance to the Peak of Teneriffe, and Adam's Peak in the island of Ceylon. But in the third place, the chief features of the mountain scenery of the moon consist in those circular ranges of mountains which occupy nearly one-half of the lunar surface, and are dispersed in all directions. In some cases, they appear like a wall of sixty, one hundred, or one hundred and fifty miles in circumference, surrounding circular plains of corresponding extent. In other cases, they are from five to ten or twelve miles in diameter; and in many instances there is a central mountain of a considerable elevation, which rises from the centre of the circular plain. There is nothing similar to these arrangements in any part of our terrestrial system. The lunar mountains, according to Schroeter's measurements, are of all sizes, from three hundred feet to five miles in perpendicular height. 3. Another singular feature of the moon's surface consists in those numerous depressions, or cavities, which appear on almost every part of her disk. These cavities are circular, and bear a certain resemblance in shape to an egg-cup. A high annular ridge, marked with lofty peaks and small cavities, generally encircles them, an insulated mountain frequently rises in the centre, and sometimes they contain smaller cavities of the same nature as themselves. These hollows are most numerous in the south-west parts of the moon, and from this cause it is owing that that portion of the lunar surface is more brilliant than any other portion of the moon; these cavities, along with the mountainous ridges which encircle them, reflecting a greater quantity of light than any other part of the lunar regions. As to their dimensions, they are of all sizes, from three miles to fifty miles in diameter at their orifices, but they generally decrease in breadth towards the bottom. Their depth varies from about one-third of a mile to three miles and three quarters below the summits of the mountains which surround them; but in all cases the internal depth of the cavity is much lower than the general surface of the moon. Of this feature of the lunar surface we have no examples in any part of our globe; but we have reason to believe, from the variety which exists in nature, that not one world in the universe exactly resembles another in its particular arrangements.

The following figures will perhaps convey a rude idea of some of the objects on the lunar surface now described. Fig. 36 is a view of the brilliant spot called Aristarchus, which is situate in the north-east quadrant of the moon's surface,

Figure 36.

Figure 37.

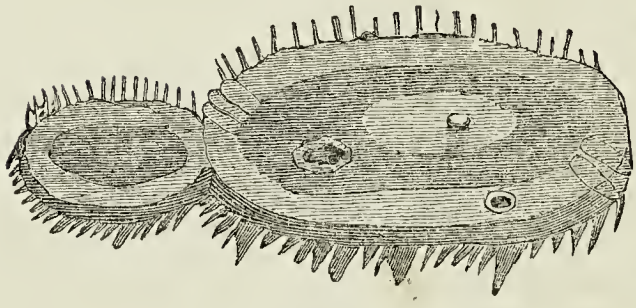


Figure 38.

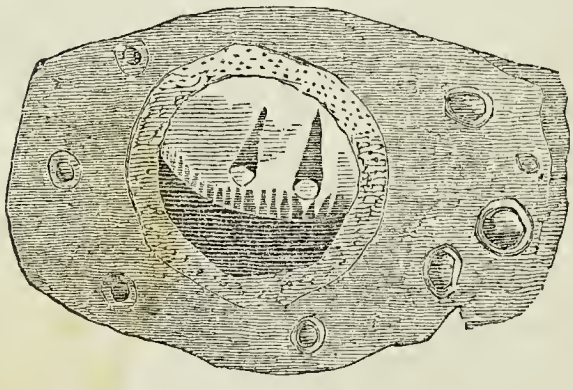
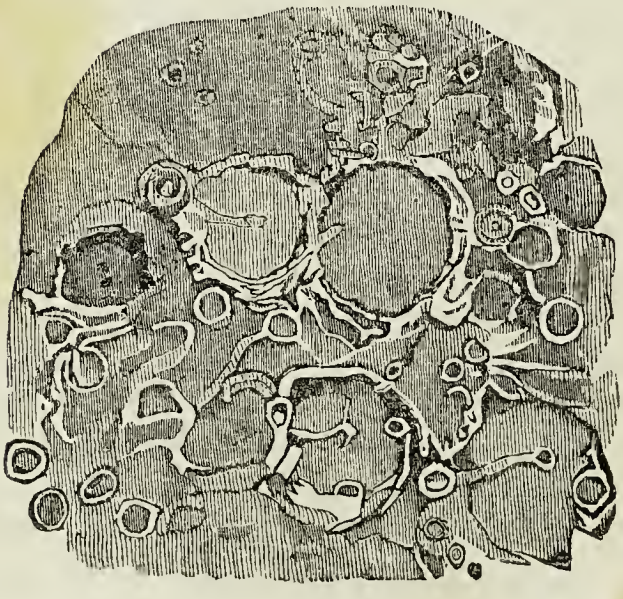


Figure 39.



where the shadows of some of the circular cavities and also the shadows of the mountains may be perceived. Fig. 37 is the spot called Hevelius, which contains an annular cavity, and a broken elevation somewhat resembling an egg. Fig. 38 represents a cavity surrounded by a circular range of mountains, with two central mountains in the middle of the plain, in which the shadows of one side of the circular range and of the central mountains may be seen. Fig. 39 shows another magnified portion of the moon's disk, exhibiting several circular plains, cavities, and other varieties of the lunar surface.

From what we have now briefly stated, it is evident that an immense variety of picturesque and sublime scenery is presented to view on the surface of the moon, and could we conceive ourselves standing on some of her lofty peaks, her circular mountain ridges, or on the summit of her central mountain, we should behold a much greater extent of prospect, and an assemblage of more grand and sublime objects than is presented to our view in any of our terrestrial landscapes. The best time for viewing all the varieties of scenery on the moon's surface, with a telescope, is about the period of half-moon, or two or three days before or after it, at which times the shadows of the lunar mountains and cavities are longest and most distinct. At the time of full moon, many of the objects described above cannot be perceived, as the sun then shines perpendicularly upon the moon's surface, so that the shadows of the different objects cannot be distinguished. The following additional particulars respecting the moon may be stated.

1. The length of a lunar day is equal to nearly fifteen of our days, and the length of the night the same, so that a day and night in the moon is equal to twenty-nine days and a half, or one lunar month. On the hemisphere next the earth, there is moonlight nearly all the time the sun is absent; but in the other hemisphere, in the absence of the sun, there is no light but what proceeds from the stars and planets. Were a lunarian to travel, at the rate of ten miles an hour, in a direction at right angles to the moon's axis, he might keep pace with the moon's rotation, and be enabled to live in perpetual sunshine. 2. The light of the moon has been computed to be 300,000 times less intense than that of the sun, when shining in an unclouded sky; yet its utility is considerable, and when the full moon shines in its splendour, it throws a cheerful, though mild light over the surrounding landscape. 3. The nearer the moon is to the periods of new

and full moon, the greater is her velocity in her orbit; and the nearer she is to the quadratures, the slower she moves. When the earth is in its perihelion, or nearest the sun, which happens in the winter, the periodical time of the moon is greatest; and when the earth is in its aphelion, which happens in summer, the periodical time of the moon is the least. 4. The mean inclination of the moon's orbit to that of the earth is five degrees, nine minutes. 5. The eccentricity of her orbit is 12,960 miles. 6. The moon in all probability is surrounded with an atmosphere, but it is evidently a very small one, and of extreme tenuity; and no clouds or vapours appear to exist in it. It is stated as having been distinctly perceived during the annular eclipse of May, 1836, when just before the rims of the two bodies met, the light of the sun was seen to shoot through the moon's atmosphere, mollified into twilight. Schroeter calculates its height at 5742 feet.

There can be little doubt that the moon, like the earth on which we dwell, is a world replenished with inhabitants. Matter appears to have been created chiefly in subserviency to mind; and it is highly improbable that the Creator would leave a globe containing a surface of fifteen millions of square miles altogether destitute of sensitive and intellectual beings, especially when we behold its surface diversified and adorned with such a vast assemblage of picturesque and sublime scenery, and when we consider that every department connected with our globe is peopled with sentient beings of every description. Although seas and rivers and a dense atmosphere are not to be found connected with the lunar orb, and although some of its arrangements are different from those of the earth, yet these circumstances form no valid objection to the moon being inhabited, for the Creator can in all cases adapt the inhabitant to the nature of the habitation provided for him, as he has adapted the birds for winging their flight through the air, the fishes for gliding in the waters, and man and quadrupeds for traversing the dry land.

It has frequently been a subject of inquiry, Whether the inhabitants of the moon may ever be discovered by the inhabitants of our globe? Notwithstanding the improvements that have been made on telescopes in modern times, we have no expectations that such a discovery will ever be made. Even the large telescope lately constructed by the Earl of Rosse, however distinct and beautiful a view it may exhibit of the mountains and vales, rocks and caverns, on the lunar surface, will never be able to show us its inhabitants, although they had bodies five hundred times larger than those of the

inhabitants of the earth. That telescope has seldom been used with powers exceeding eight hundred times; but although a power of two thousand times could be put upon it with distinctness, it would make the moon appear no nearer to us than one hundred and twenty miles, at which distance a living being, although a hundred feet high, could not be beheld. For, with such a power, a space on the moon's surface one hundred and eighty-three feet in diameter could only be perceived as the smallest visible point. Besides, we ought to consider that when we view objects on the surface of the moon, we do not view them in perspective, as we view objects on the surface of the earth, but only obtain a bird's-eye view, as we do of objects on the surface of our globe, when viewed from a balloon suspended in the atmosphere, in which case, when we look down upon a group of human beings, we perceive only the length and breadth of their heads and shoulders.

There is a possibility, however, of tracing the operations of sensitive, or intelligent beings, in the lunar orb, although we can never expect to trace the forms or motions of its inhabitants. Were a vast number of persons in different parts of the world to devote themselves to a particular survey of the moon—were different portions of its surface allotted to different individuals as the object of their particular research—were accurate observations made, and frequently repeated, on every mountain, hill, cavity, cliff, and plain, and every change and modification in the particular spots and their localities carefully marked and represented in a series of delineations, it might lead to some certain conclusion both as to the physical constitution of the moon, and as to whether any of the observed changes proceeded from the operations of living agents. If an observer in the moon, with such a telescope as Sir William Herschel's, or that of the Earl of Rosse, had observed the city of Babylon, when in its splendour, and afterwards when reduced to a desert, as it now is, he must have observed a change in the locality where that famous city once stood, indicative of the operations of intelligent, or at least, of sensitive, or living agents. And had he viewed the dense forests of America before civilized nations took possession of that country, and were he now to take a view of the eastern states of North America, in their present state of cultivation, and since the great cities of New York, Boston, and Philadelphia were reared, a striking difference between the present and the former state of that country would doubtless be perceptible. For, if an extent of only one hundred and eighty-three

feet, or sixty-one yards, would be perceptible by a telescope magnifying two thousand times, much more would the extent of a large city, such as New York, be distinctly visible, as a prominent and well-defined object. Now, if changes similar, or analogous to these, could be traced on the surface of the moon, it would lead us to form some certain conclusions in relation to the operations of intelligent agents, and consequently, that such beings actually exist on the lunar surface. But such observations as those to which we allude would require not only to be specific and minute, but also to be continued for a length of years—perhaps a century or more—before any striking changes could be expected to occur.

Dr. Olbers was fully of opinion, from the observations he had made, "that the moon is inhabited by rational creatures, and that its surface is more or less covered with a vegetation not very dissimilar to that of our earth." It has formed a subject of speculation with some, whether it might be possible to correspond with the lunar inhabitants by symbolical representations. If they be mathematicians, it has been conceived that the erection of geometrical figures on some extensive plains on our globe, on a scale of vast extent, might be recognised by the inhabitants of the moon, as a signal of correspondence, and that they might erect similar figures in return. But it is highly questionable whether the design of such figures would be appreciated, or whether they would be visible to the eyes of the inhabitants. Many a look, we may conceive, will be directed to our globe by the lunar inhabitants, and much wonder will doubtless be expressed at such a large globe hanging over their heads, apparently immovable, excepting a rotation round its axis; and much speculation will, without question, take place among them as to whether such a globe as ours be inhabited. But it does not appear to be the design of the Creator, in the mean time, that the inhabitants of our globe and those of the moon should become acquainted, or that any direct correspondence should take place between different worlds. And therefore, we must wait with patience till the scenes of a future life shall unravel the mysteries, and dispel the darkness which now hangs over the history, the population, and the transactions of other worlds. Whatever may be the peculiar circumstances of the beings that people other globes, we know that they are all under the care and superintendence of Him who is infinite in wisdom, power, and intelligence; whose "kingdom ruleth over all," and whose "tender mercies are over all his works."

But, whatever opinions we may entertain respecting the

inhabitants of the moon, certain it is that she forms a beautiful and noble appendage to our globe, and her light and motions are of high utility to its inhabitants. How cheerless and uncomfortable, in many cases, would be our nights, were it not for the mild radiance which the lunar orb dispenses in such regular and agreeable vicissitude! To the mariner, while ploughing his course through the stormy deep; to the ploughman, "plodding his weary way;" to the peasant, pursuing his course through moors and morasses after nightfall; to the shepherd, tending his fleecy charge by night; to travellers in foreign lands; and to the missionary in pagan countries, when returning at midnight from his sacred labours; the moon, in her various stages, is always a most cheerful and welcome visitant. She throws a mild and silvery lustre over the forests, the mountains and the vales, and we behold a new picture of terrestrial objects, which is more delicately shaded, and disposed into softer lights than that which is displayed under the blaze of the meridian sun—a scene which leads the pensive mind to pleasing reflections, and to solemn contemplation. By her attractive influence, she sways the ocean, and perpetuates the regular returns of ebb and flow, by which the liquid element is preserved from putrefaction, and the inhabitants of the islands and continents from infection and disease. And, although her brightness is not the same at all seasons, and though she is sometimes absent from our nocturnal hemisphere, yet, in her absence, we enjoy, on a clear evening, a more extensive prospect of the starry regions, and of those remote spaces of creation where suns unnumbered shine, and planets and comets run their solemn rounds. Let us then be grateful to our beneficent Creator, who, in this as well as in all his other works, has displayed his infinite wisdom, and his unbounded goodness; and let us, in unison with the inspired writers, praise the name of the Lord, who hath appointed "the moon to rule by night," as an evidence of his fatherly care, and of his mercy, which "endureth for ever."

CHAPTER IV.

DESCRIPTION OF THE SUPERIOR PLANETS OF THE SOLAR SYSTEM.

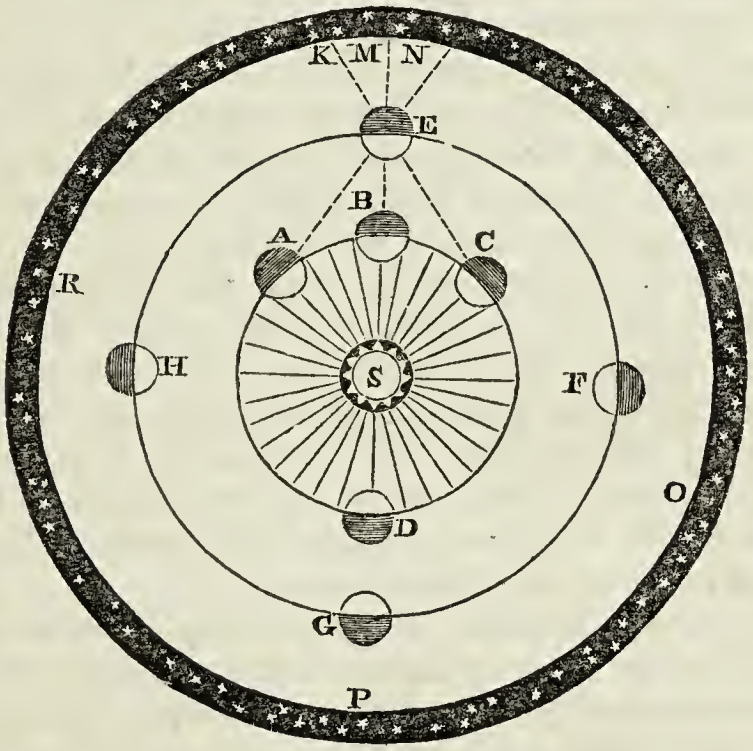
SEC. I.—ON THE MOTIONS AND ASPECTS OF THE SUPERIOR PLANETS.

The planets Mercury and Venus, whose motions and phases we formerly described, are called inferior planets, because they revolve round the central luminary in orbits which are included within the orbit of the earth, and consequently nearer the sun than the earth is. The superior planets are those whose orbits are without that of the earth, and, of course, at a greater distance from the sun. The superior planets are Mars, Vesta, Juno, Ceres, Pallas, Astræa, Jupiter, Saturn, and Uranus. They are distinguished from the inferior planets in the following respects:—1. They come to our meridian at midnight, which the inferior planets never do. 2. They are sometimes seen rising in the east, when the sun is setting in the west; a circumstance which never happens to Mercury or Venus. 3. While the inferior planets always appear to move in the neighbourhood of the sun, never removing beyond forty-eight degrees of that luminary, the superior planets may be seen at all distances from the sun, and even in the opposite quarter of the heavens. 4. The superior planets never can appear to transit the sun's disk, as Mercury and Venus have been seen to do at different periods. 5. The superior planets never appear in the form of a crescent, or of a half-moon, as the two inferior planets are found to do in certain parts of their orbits. They always appear with a round face, when viewed with a telescope, except Mars, which sometimes appears with a slight gibbous phase. 6. A superior planet can only be in conjunction with the sun, when the sun is between the earth and the planet; whereas an inferior planet may be in conjunction with the sun, when it is between the sun and the earth. 7. There are also certain peculiarities in reference to the direct and retrograde motions of the superior planets, and the points in which they appear stationary, different from those of the inferior planets. All these circumstances clearly show, that

the path of the earth round the sun is included within the orbits of the superior planets; that we occupy a station that is never very far removed from the centre of their orbits, and that we see these planets in a direction which is nearly that in which the sun's rays enlighten them.

Apparent motions of the superior Planets as seen from the Earth.—The superior planets are retrograde when seen in opposition to the sun, that is, they appear to move from east to west, or contrary to the order of the signs of the zodiac; and their motion appears direct, or from west to east, when in conjunction with the sun. The following diagram, fig. 39,* will illustrate some of the motions and aspects of these planets. Let the central circle S represent the sun, A B C D the orbit of the earth; E F G H the orbit of a superior planet,

Figure 39.*



suppose that of Mars, and K M N O P R a portion of the starry heavens. When the earth is at D, and Mars at E, the planet, as seen from the earth at D, will appear in the same part of the heavens as the sun, or in conjunction with him. When the earth is at B and the planet at E, it is then said to be in opposition to the sun; for the sun is then seen in the direction S P, while the planet is seen in the direction B M. In this case, the planet is nearest to the earth, and in the case of Mars, it is only fifty millions of miles distant from us. But

when the earth is at B and Mars at G, the planet is the whole diameter of the earth's orbit, or one hundred and ninety millions of miles farther distant, and consequently, at that time, two hundred and forty millions of miles from the earth. Hence it happens that this planet appears about twenty-five times larger in the one case than in the other. When farthest distant from the earth, it appears like a small star; but when nearest us, it appears nearly as large as Jupiter or Venus, but with a more ruddy aspect. These circumstances clearly prove that Mars does not move round the earth as its centre of motion, as the ancients supposed, but round the sun, and that, too, in an orbit which includes the earth's orbit within it.

The cause of the direct and retrograde motions of the superior planets will likewise appear from fig. 39. Suppose the earth at A, and Mars at E, while the earth is moving through the part of its orbit A D C, the planet will appear to move from N to K among the stars, which is its direct motion through the heavens, or from west to east; so that when the earth is at D, the planet will appear at M, and when the earth is at C, it will appear at K. But while the earth moves through C B A to A, it will appear to return to N, having a retrograde motion from east to west; so that when the earth is at B, it will appear to be at M, and when the earth is at A, it will appear to have returned back to N. When the earth is either at A or C, the planet will appear stationary for a few days. The direct motion is very slow from N to K, because the earth has to move, during its continuance, through the large part of its orbit A D C; but the retrograde motion, from K to N, is performed in much less time, because the earth, while it continues, has to move only from C to A.

We have supposed the planet at rest, in order to avoid complexity in the illustration; but the appearances will be the same, whether we conceive the planet at rest or in motion; only the time in which the direct and retrograde motions are performed will be different when we view the planet as in motion. Jupiter, Saturn, and all the other superior planets have similar direct and retrograde motions and stationary positions. They all retrograde when in opposition, and for some time before and after it; but they differ greatly as to the time of its duration. It is more rapid and extensive in the case of Mars than of the other planets which are farther distant from the sun. It may just be farther stated, that the times of the conjunctions, oppositions, direct and retrograde motions, and also of the stations of the superior planets

depend upon the combinations of their motions in their orbits with the motion of the earth in its orbit; and this combination causes all the apparent irregularities which appear in the motions both of the superior and inferior planets. But all the planets, if viewed from the sun, the centre of their motions, will appear to move without interruption in the same direction; only moving somewhat more slowly in their Aphelion, and more swiftly in their Perihelion.*

SEC. II.—ON THE PLANET MARS.

This is the first of the superior planets next to the earth. Its name, which was given by the ancients, signifies "the god of war," which appears to have been given on account of its ruddy or fiery appearance, and because the astrologers imagined it to be a promoter of war and bloodshed. It is rather unfortunate that the names of the planets, as well as of the celestial constellations, should all be derived from heathen mythology, and from the superstitious and idolatrous views of the ancients. It ill comports with the peaceable study of astronomy that a god of war should be supposed riding in his fiery chariot through the heavens, and brandishing his sword over the nations to excite them to diabolical contests. It presents a melancholy and degrading picture of human nature, that in all ages war has produced its horrid massacres and devastations among every kindred, and in every clime, and that men should have imagined that a celestial deity was appointed to preside over its infernal operations, and to "urge the foes to battle." It will be to the eternal dishonour of the human character, that ever such malignant exploits were engaged in, in our terrestrial sphere. In modern times, it is an indelible disgrace to nations, who designate themselves as civilized and enlightened, that such a mode of settling disputes between states and empires should be resorted to as that of warfare. It is glaringly unchristian; it is inhuman and atrocious; it is a violation of the fundamental laws which unite the moral universe; it is accompanied with almost all the evils which can afflict humanity; it is subversive of the wealth and prosperity of nations; and it must be highly offensive to the Creator, who has so curiously constructed the human frame, and formed man "after his

* The Aphelion is that point of the orbit of the earth, or of any other planet, which is farthest from the sun; and the Perihelion is that point in the orbit of a planet which is nearest to the sun. As the planets move in elliptical orbits, they must, of course, be at different distances from the sun in different parts of their orbits.—See Appendix, No. III.

own image," that such an exquisite structure should be cut and slashed and destroyed by those who are partakers of the same nature. In short, it conveys an absurdity in the very idea of it; for it never can decide on which side of a disputed question justice and right are to be found; and it degrades man, who is endowed with high intellectual powers, to a level with the inferior animals—with the bear, the lion, and the hyena, that have no other mode of settling their disputes but by physical force. Scarcely any thing can be more degrading and monstrous, in beings furnished with moral faculties, and endowed with reason and intelligence. But it is needless to say that the planet Mars, though somewhat more ruddy than the other planets, has no influence whatever over such barbarous and malignant exploits. It sweeps along in its course through the heavens, in unison with the other bodies which compose the solar system, in obedience to a universal law, and displays, in its motions, its Creator's power and wisdom.

The distance of this planet from the sun is one hundred and forty-five millions of miles, and the circumference of its orbit about nine hundred millions of miles. The distance of its orbit from that of the earth is fifty millions of miles; and, at the time of its opposition to the sun, it is about this distance from the earth—which is the nearest approach to the earth which any primary planet can make, the planet Venus only excepted. It accomplishes its revolution round the sun in six hundred and eighty-seven days, or about one year and ten months, which is at the rate of fifty-four thousand miles an hour—a rapidity of motion which affords a striking idea of the omnipotent energies of the Creator. But before it can return to the same relative position in regard to the sun, or, in other words, from one conjunction or opposition to another, it occupies a period of seven hundred and eighty days—that is, two years and fifty days. It is only at the period of its opposition, when it is nearest the earth, and a short time before and after it, that this planet makes its most splendid appearance, almost rivalling Jupiter in its lustre; and therefore, before we can again see it with the same degree of lustre, a period of two years and fifty days, at an average, must elapse. It was in this position in June, 1843; again in August, 1845; and again in October, 1847. This is the most eligible period for observing the surface of Mars through telescopes, and, likewise, for observing its direct and retrograde motions. From spots which have been observed on the surface of Mars by the telescope, it was determined that it makes a revolution round its axis in twenty-four hours and nearly

forty minutes—which is only forty-four minutes longer than the diurnal rotation of the earth, and is performed in the same direction, namely, from west to east. Its axis is inclined to the plane of the ecliptic at an angle of nearly sixty degrees, or about thirty degrees from the perpendicular. Of course, there must be different lengths of days and nights in different regions of this planet; and, likewise, a diversity of seasons, somewhat similar to what we experience on our globe.

This planet, as to size, ranks among the smaller bodies of the solar system. Its dimensions are as follows:—Its diameter is found to be about four thousand two hundred miles—which is little more than half the diameter of our globe. Its surface contains above fifty-five millions of square miles, which is several millions more than the number of square miles on the habitable parts of the earth. Were its whole surface composed of land, and were it peopled in the same proportion as Belgium—three hundred inhabitants to a square mile—it could contain a population of sixteen thousand five hundred millions, or more than twenty times the present population of our globe; so that this planet, though comparatively a small one, may rank higher than even our world in respect to the number of sensitive and intellectual beings it may contain. This planet, like the earth and several other planets, is of a spheroidal figure, its polar diameter being about two hundred and sixty miles shorter than its equatorial.

When viewed with good telescopes, spots of various forms have been discovered on the disk of Mars. It was, however, more than fifty years after the invention of the telescope, before any discoveries were made on the surface of this planet, or any spots could be seen to determine its rotation. Cassini, an Italian astronomer, about the year 1666, was among the first who perceived several dark spots on the surface of Mars; and Dr. Hooke, in England, and Campani, at Rome, about the same time, made similar observations. It was found that all the features which the planet exhibits at any moment, gradually disappeared in twelve hours and twenty minutes, at the expiration of which time it exhibits an entirely different appearance; and, by continuing to observe its disk, the former features were seen to come successively into view—and thus was its revolution round its axis ascertained, and the period of it accurately determined. Some observers have remarked that these spots do not always appear well defined, and that they frequently change their form; but that some of them continue always the same. It appears probable that clouds exist in the atmosphere of Mars,

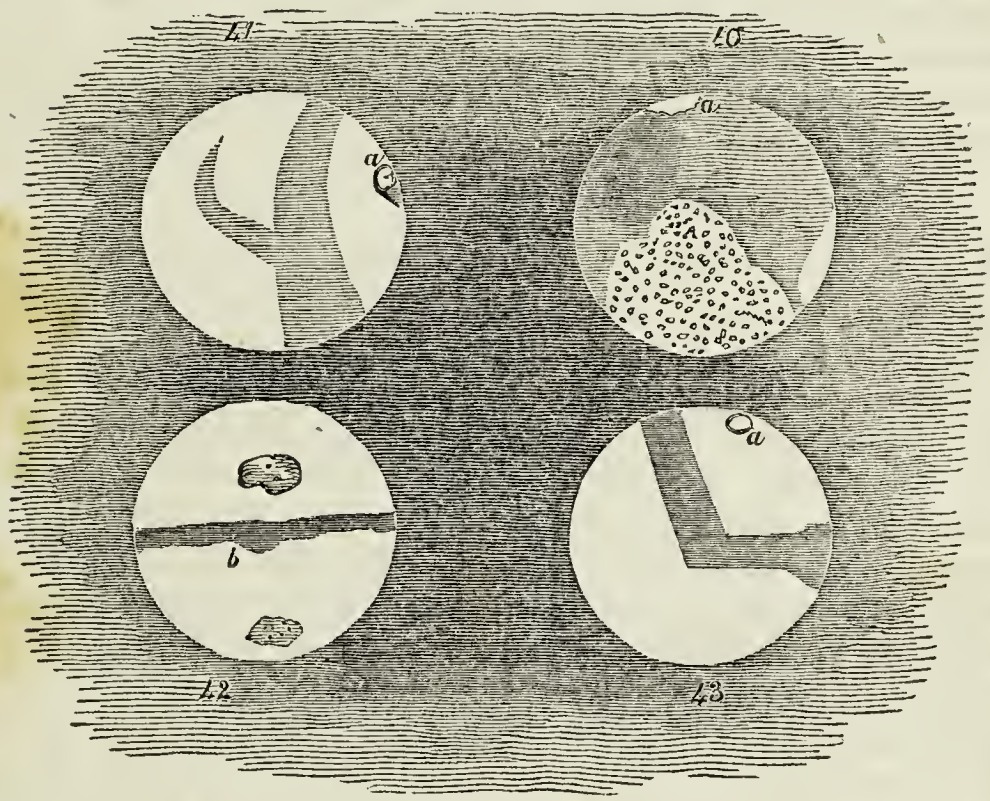
and that these, being occasionally interposed between the eye of the observer and the surface of the planet, may cause the changes of appearance which have been observed. It is admitted by all astronomers that an atmosphere, or body of air, of considerable density and extent, surrounds this planet; for it is found that small stars, as they approach the edge of its disk, suffer a gradual diminution in brightness, before they disappear, by the interposition of its body; and this obscurity of a star, when seen in such circumstances, must arise from its being viewed through a dense medium connected with the planet. The circumstance, therefore, of an atmosphere around Mars, combined with the fact that it has a revolution round its axis, to produce the alternate succession of day and night, forms a strong presumptive proof that this planet is an inhabited world, and destined to afford existence and happiness to numerous orders of beings.

There is an intensely white spot which has been long observed around the pole of Mars, when, emerging from darkness, it first receives the sun's light; and this gradually diminishes in magnitude and brightness till the pole again withdraws itself from the sun; and as regularly and certainly re-appearing, when the same pole emerges from the cold and darkness of its winter. For as the axis of Mars is inclined to its ecliptic, or the plane of its orbit, one of its poles is deprived of the solar light during eleven months, or one-half of its year, in the same manner as the north pole of our globe is in darkness from the end of September to the 21st of March. Now, it has been supposed that, during this long winter of eleven months in the polar regions of Mars, these regions are covered with snow, which is the cause of the white appearance about the poles, when these poles emerge from darkness; and, after long exposure to the sun's rays, during the other eleven months, when the sun is shining upon them without interruption, these polar snows are gradually dissolved, so as to leave the naked soil of that region exposed to view.

The following are the results of Sir John Herschel's observations on this planet, made with a twenty-feet reflecting telescope. He says that, on account of the clearness of its atmosphere, he has been enabled to observe, with perfect distinctness, the outlines of continents and oceans; that the land on its surface is distinguished by a red hue, which imparts to the planet the ruddy appearance it has when viewed by ordinary telescopes, and which its light exhibits to the naked eye. This redness he ascribes to a quality in the prevailing

soil, like that which our red sandstone districts would exhibit to an observer contemplating the earth from the surface of Mars. The seas of this planet, he observes, have a greenish hue, altogether resembling the colour of our own. These spots, however, are not always to be seen equally distinct, because of the varying transparency of the atmosphere; but when they are distinctly seen, they always present the same appearance. The following are some of the telescopic views

Figures 40–43.



which have been taken of this planet. Fig. 40 is one of the views taken by Sir J. Herschel with his twenty-feet reflector. The dark portions are considered to be water, and the white spaces land—at *a* is the white polar spot described above. Fig. 41 is one of the views given by Sir W. Herschel, which presents the appearance of a portion of a sea, with a gulf running up into the land. Fig. 42 is a view of Jupiter given by Maruldi, which he observed in 1704, and, by means of the prominence marked *b*, he determined the period of rotation. Fig. 43 is a view of Mars, which we have several times observed about the time of its opposition to the sun.

From the whole of what has been now stated respecting this planet, the following conclusions may, with a high degree of probability, be deduced—that it is environed with an atmosphere of considerable extent, in which clouds probably

exist; that the dark spots are water, or seas, which reflect a much less proportion of the solar light than land, and probably cover about one-third of its surface; that a variety of seasons, somewhat similar to ours, must be experienced in this planet, but of a much longer duration; and that it bears a more striking resemblance to the world in which we dwell than any other planet of the solar system. It was owing to observations made on this planet by the famous astronomer, Tycho Brahe, and to the records of his observations having fallen into the hands of Kepler, that the three great laws of planetary motion, generally termed "Kepler's Laws," were discovered. These laws, which we may afterwards notice, lie at the foundation of modern astronomical science, and give precision to its principles.

SEC. III.—ON THE NEW PLANETS.

Within the limits of the present century, four new planetary bodies have been discovered, none of which was known to former astronomers. They are named Vesta, Juno, Ceres, and Pallas. They are all situate beyond the orbit of Mars, and within that of Jupiter, and present a variety of singular anomalies; but, as they are all invisible to the unassisted eye, and can never be noticed by common observers, we shall give only a brief sketch of their history, and their magnitudes and motions, so far as they are known. From the interval of nearly three hundred and fifty millions of miles which lies between the orbits of Mars and Jupiter, it was long conjectured, as highly probable, that some undiscovered planet either exists, or had existed, in some part of this vast region, so as to present something like proportion in the arrangements of the system, when compared with the distances which intervene between the orbits of Mercury, Venus, the Earth, and Mars. This conjecture may be considered as having been in some degree realized by the discovery of four small bodies, situate in orbits at no great distance from each other, at an average of about a hundred millions of miles beyond the orbit of Mars.

History of their Discovery.—The first of these bodies which was discovered, was the planet Ceres. It was discovered at Palermo, by Piazzi, a Sicilian astronomer, in the constellation Taurus, on the 1st of January, 1801—being the first day of the present century—and within the limits of the next seven years, all the other three bodies were discovered. After being lost for some time, it was re-discovered by Dr. Olbers, of Bremen, after a series of unwearied observations—

when its motions and position in the system were determined—since which time, its place in the heavens can always be ascertained. Only fifteen months elapsed, after the discovery of Ceres, when Dr. Olbers, on the 28th of March, 1802, discovered the planet Pallas. The planet Juno was discovered on the 1st of September, 1804, at the observatory of Lilienthal, near Bremen, by M. Harding, while he was endeavouring to form an atlas of all the stars near the orbits of Ceres and Pallas, with the view of making further discoveries. The planet Vesta was discovered on the 29th of March, 1807, by Dr. Olbers, who had previously discovered Pallas. He had previously conjectured that the three small celestial bodies, lately discovered, were merely the fragments of a larger planet, which had been burst asunder by some internal convulsion, and that several more might yet be discovered between the orbits of Mars and Jupiter. On this hypothesis he concluded that, as these fragments must all have diverged from the same point, they ought to have two common points of reunion, or two nodes in opposite regions of the heavens, through which all the planetary fragments must sooner or later pass. One of these nodes he found to be in the sign Virgo, and the other in the constellation of the Whale—and it was actually in the Whale that Mr. Harding discovered the planet Juno. Therefore, with the intention of discovering other fragments of the supposed planet, if any should exist, Dr. Olbers examined, three times every year, all the small stars in the opposite constellations of Virgo and the Whale—and his labours were crowned with success, by the discovery of a new planet, in Virgo, to which he gave the name of Vesta.

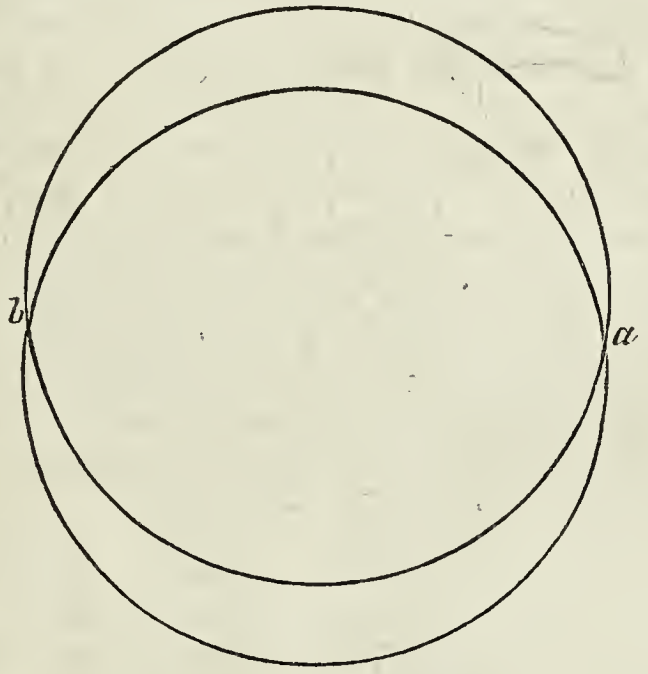
The magnitudes of these bodies, on account of their comparatively small size, and the difficulty of measuring their apparent diameters, have not yet been accurately determined. The following is a brief summary of what has been ascertained respecting their distances, motions and magnitudes. The planet Vesta, which was last discovered, is considered as the nearest to the sun. Its distance from that luminary is reckoned to be about 225 millions of miles, and it revolves about the sun in 1325 days, or in three years seven months and a half, moving at the rate of 44,000 miles an hour. Some have estimated its diameter at 276 miles, and if so, it will contain 229,000 square miles on its surface. But it is probable, from a variety of circumstances, that it is considerably larger in size than what is here stated. The distance of Juno from the sun is 254 millions of miles, and it accomplishes its

revolution in four years and one hundred and twenty-eight days, at the rate of 41,850 miles an hour. Its diameter is estimated by certain German astronomers, at 1425 English miles. It is of a reddish colour, and is free from any nebulosity, and is supposed to be environed with a dense atmosphere. The planet Ceres is 263 millions of miles from the sun, and finishes its revolution in four years, seven months, and ten days. Its real diameter is estimated at 1624 miles, so that its surface will contain more than eight millions of square miles; but its atmosphere is reckoned at about 675 miles in height. It is of a slight ruddy colour, and appears like a star of the eighth magnitude. The planet Pallas is distant from the sun about 263 millions of miles, or about the same distance as Ceres, and completes its revolution in four years seven months and one-third of a month, which is within a day of the time of the revolution of Ceres. Schroeter, a German astronomer, considered this planet as the largest of the four, and he estimated its diameter to be 2099 miles, and consequently nearly the size of our moon. It presents a ruddy aspect, and is surrounded with a nebulosity, somewhat like Ceres, but not so extensive. It is distinguished from all the other planets by the very great inclination of its orbit to the plane of the ecliptic, which is no less than thirty-four degrees thirty-seven minutes.

These four planets present to our view certain singularities and anomalies, which, at first view, appear incompatible with the harmony and proportions which we might suppose originally to have characterized the arrangements of the planetary system. 1. Their orbits are in general more eccentric than those of the other planets; in other words, they move in longer and narrower ellipses. The eccentricities of the orbits of Juno and Pallas amount nearly to one-eighth part of the transverse axes of their orbits; whereas the eccentricities of the orbits of Jupiter and Uranus are only the one forty-third part, and that of the earth, one hundred and nineteenth. Hence it follows, that Pallas and Juno will sometimes be 129 millions of miles farther from the sun at one period than at another. 2. Their orbits have a much greater degree of inclination to the ecliptic than those of the other planets; that of Pallas being no less than thirty-four degrees and a half, which is twenty-seven times greater than that of Jupiter. 3. They revolve nearly at the same mean distance from the sun. The mean distance of Juno is 254,000,000, of Ceres 262,903,000, and of Pallas 262,901,000 of miles, while in the case of all the other planets, many

millions of miles, sometimes amounting to hundreds, intervene between their orbits. 4. They perform their revolutions in nearly the same periods. The period of Juno is four years four months and a half; of Ceres, four years seven months and a half; and of Pallas, four years seven months and a half; whereas the periods of the old planets differ very considerably from each other: that of Mars being less than two years; that of Jupiter, twelve years; of Saturn, nearly thirty years; and of Uranus, eighty-four years. 5. The orbits of some of these planets cross each other. This is a very singular and unaccountable circumstance in regard to planetary orbits, and cannot possibly happen in the case of the other planets, or of any of their satellites. This is represented in the following diagram, fig. 44. The orbit of Vesta crosses

Figure 44.



the orbits of the other three, and therefore it is a possible circumstance that a collision might take place between Vesta and these three planets at the points of intersection *a* and *b*; and were it ever to happen, the consequences would be dreadful to both planets.

Within a very short period, a new planet has been discovered by Mr. Hencke, of Driessen, in Prussia. It appeared like a star of the ninth magnitude, in a place where, before, there was none. This discovery was made on the eighth of December, 1845. Its place on December the fourteenth, as found by Professor Encke, of Berlin, at six hours twenty-eight minutes, was, right ascension, 64 deg. 4 min. 53 sec. At thirteen hours, 34 min. 55 sec., its right ascension in time

was 4 hours, 16 min. 2 sec. Declination north, 12 deg. 39 min. 53 sec. At fourteen hours, 33 min. 27 sec. Right ascension in time, 4 hours 16 min. Declination north, 12 deg. 39 min. 52 sec. Its motion was retrograde, and its daily amount, as determined from the observations, 8 hours apart, was, in right ascension, 14 min. 21 sec. In declination, its motion was quite insignificant. This moving body was afterwards observed in England by Messrs. South, Airy, and others; and from their observations and those of foreign astronomers, it has now been determined to be a planet belonging to the solar system, to which the name Astræa has been given.

From the notes of Astræa's position given by Encke and Schumacher, M. Faye, a French astronomer, has calculated the elements of its orbit. They are as follows:—

	Deg.	Min.
Epoch, 1845, Dec. 14	71	13·6
Longitude of ascending node	135	14·6
Inclination	6	1·2
Semidiameter of orbit	26,024	
Movement	direct	

Period of sidereal revolution, 4 years 2 months.

It appears, therefore, that Astræa has a certain relation to the four minor planets, revolving between Mars and Jupiter, which were discovered about the beginning of the present century. This relation will appear at once when their elements are compared, as in the following statement:—

	Mean dist. from the sun.	Mean period in days.	Inclination of orbit.		
Vesta	2·3678	1325	7°	8′	9″
Juno	2·6690	1592	13	4	9
Ceres	2·7672	1681	10	37	26
Pallas	2·7728	1686	34	34	55
Astræa . . .	2·6024	1521	6	1	2

In the element of distance, that of the earth from the sun is taken as a unit. The distance of Astræa from the sun is to that of the earth as 2·6024 to 1·000, or in round numbers as 26 to 10. It follows that Astræa revolves round the central luminary at the distance of 247,000,000 miles. In its distance and period of revolution, Astræa agrees most nearly with Juno, in inclination with Vesta.

The discovery of this planet affords a strong corroboration of the hypothesis which supposes that the four new planets formerly discovered, originated from the disruption of a large planet which formerly moved between Mars and Jupiter.

Such a catastrophe is involved in a great mystery; and yet, without supposing it to have taken place, we can scarcely account for the peculiarities of these planets, which form anomalies in the solar system. It is not improbable that other bodies, originating from the same source, may yet be discovered.

Such anomalies and singularities, in the case of these lately discovered bodies—so very different from the arrangement of the other planets—have opened a field for speculation and inquiry. It has been supposed, on somewhat plausible grounds, that these planets are only the fragments of a larger planet which had been burst asunder by some immense eruptive force proceeding from its interior parts. This hypothesis accounts in a great measure for the anomalies and apparent irregularities to which we have alluded, particularly for the intersection of their orbits, and for the fact, that the planets are not round, as is indicated by the instantaneous diminution of their light, when they present their angular faces. It has also been supposed that the smaller fragments that may have escaped at the time of the disruption, may account for some of the meteoric stones which at different times have fallen from the higher regions upon our globe.

Whether we consider the present peculiarities, positions, and motions of these planets, as accordant with the state in which they were originally created, or whether we view them as the effects of some tremendous shock or disruption, there appears to be something sublimely mysterious and worthy of attention in the physical—not to say moral—arrangements of the Almighty, in the state in which these bodies are now found. If they were originally arranged in the position and order in which they now appear, they present an anomaly, a want of proportion and harmony, to whatever appears elsewhere throughout the whole range of the system. And, if their present phenomena be the effects of some dreadful concussion, the fate of the beings that inhabited the original planet must have been involved in the awful catastrophe. We need not be much surprised, although such an event should have taken place, nor should we consider it as inconsistent with what we know of the physical and moral government of the Almighty. For an event somewhat analogous happened to our own globe, at that period when "the cataracts of heaven were opened, and the fountains of the great deep were broken up," when a flood of waters ensued which covered the tops of the loftiest mountains, transformed the earth into a boundless ocean, and buried the myriads of its

population in a watery grave. And we profess to believe that a period is approaching when the great globe we inhabit shall undergo a tremendous change, and its elementary parts be dissolved, when the aërial "heavens shall pass away with a great noise, and the elements shall melt with fervent heat, the earth also, and the works that are therein shall be burned up."

All the parts of the material system are liable to change; and we have no reason to conclude, that, throughout the future periods of duration the earth is the only globe in the universe whose present constitution and aspect shall undergo an important change. As it is probable that the work of creation is incessantly going forward throughout different regions of immensity, so it is highly probable that numerous changes and renovations are taking place in those departments of creation which have long existed, in order to present new scenes and new manifestations of the perfections of the Creator to the view of the intelligent universe. For the whole system of creation appears to be in incessant motion; there is not an orb in the firmament, among all the millions it contains—whether great or small—but is in rapid and perpetual motion through the vast spaces of infinitude; and, in the course of ages, these movements, conducted by certain laws, under the direction and superintendency of the Supreme, may produce changes and revolutions which will add to the grandeur of the material universe, and excite the admiration of the intelligent system. He only is immutable who existed from eternity past, who gave birth to all created beings, whose presence fills the immensity of space, and of whose years there shall be no end. And throughout all the regions of space, so far as the material creation extends, his moral government is exercised, in a thousand different modes, corresponding to the rectitude, the wisdom, and the benevolence of his character, and the condition of the intellectual beings he has formed. For wherever power, wisdom, and intelligence are displayed, there also must all the other perfections of the Almighty be in incessant operation; and hence we are informed, that "he doth according to his will in the army of heaven" as well as among "the inhabitants of the earth."

SEC. IV.—ON THE PLANET JUPITER.

This planet is the largest body connected with the planetary system, the sun only excepted. It is situate about 232 millions of miles beyond the orbit of Pallas, 350 millions beyond the orbit of Mars, and 495 millions from the sun. When

nearest the earth, it is 400 millions of miles distant from us, and when in the remotest part of its orbit from the earth, it is 590 millions of miles distant. Notwithstanding this immense distance, owing to its great magnitude, it appears the most brilliant star in the heavens next to the planet Venus. Its revolution round the sun is accomplished in four thousand three hundred and thirty-two days and a half, or about 11 years, 10 months, and 17 days, during which it performs a circuit of more than three thousand millions of miles, at the rate of more than twenty-nine thousand miles an hour. Its diameter is no less than eighty-nine thousand miles; its circumference two hundred and seventy-nine thousand miles, and its surface twenty-four thousand eight hundred and eighty millions of square miles, which is more than one hundred and twenty-six times the area of our globe. But as globes are to each other as the cubes of their diameters, and the cube of Jupiter's diameter is 704,969,000,000,000 miles, and the cube of the earth's diameter is 498,677,257,000; divide the cube of Jupiter's diameter by that of the earth, and the quotient will be 1413; showing that Jupiter, as a solid globe, is one thousand four hundred and thirteen times larger than the earth. This huge planet moves round its axis in the space of nine hours and nearly fifty-six minutes; which is a more rapid rotation than that of any of the other planets. Its equatorial parts will move with a velocity of twenty-eight thousand miles an hour, which is twenty-seven times more rapid than the earth's rotation, by which the inhabitants at the equator are carried along at the rate of 1037 miles an hour. The rotation of this planet was first determined about the year 1665, by Cassini, by observing the gradual motion and revolution of a spot which appeared to move from one side to another of its disk, and returned again to the same point in nine hours and fifty-six minutes, and as the spot was evidently connected with the body of the planet, the conclusion was evident, that the planet itself turned round its axis. Hence we learn, that there is an alternate succession of day and night on Jupiter, analogous to that which we experience on the earth; but the days and nights are much shorter than ours, and the sun and the moons which belong to this planet, together with the whole frame of the heavens, will appear to move around it with a much greater rapidity than what appears from our terrestrial habitation.

The axis of this planet being nearly perpendicular to the plane of its orbit, it cannot have the same variety of seasons as the earth and Mars. Its inclination, however, is three de-

grees, five minutes, which will produce a slight change of seasons both in the polar and equatorial regions. Had the axis been as much inclined to the orbit as in the case of the earth, the polar regions would have been deprived of the light of the sun for nearly six years without interruption. And although the light and heat of these regions cannot be so great as in other parts of the planet, yet there are many ways unknown to us, by which the All-wise and Beneficent Creator may render every region of this globe a comfortable habitation for both sensitive and intelligent beings.

The apparent motion of this planet, like that of Mars, formerly explained, is sometimes direct, sometimes retrograde, and sometimes stationary. Its retrograde motion commences or finishes when it is at a distance from the sun, which varies from $113\frac{1}{2}$ to $116\frac{1}{2}$ degrees. The arc which it describes in this case varies from 9 degrees, 59 minutes, to 9 degrees, 51 minutes, and its period of duration from 116 days, 18 hours, to 122 days, 12 hours. Its apparent motion through the signs of the zodiac is, at an average, at the rate of a little more than thirty degrees in a year. It is at present, (April, 1846,) near the beginning of the sign Gemini, and will be in opposition to the sun on the 3d of December, about which period it rises near the time of sunset, in a direction nearly north-east, and will be seen shining in all its splendour, in a clear evening, till five or six o'clock the next morning. During the following years, it will be somewhat more than a month later, every year, before it arrive at its opposition: but it will be a conspicuous object in the heavens, during the winter evenings, for several successive years; and as it is the most brilliant planet in the heavens—with the exception of Venus—it is easily distinguishable from all the surrounding stars, by its superior lustre.

This planet, when viewed through a good telescope, presents a very splendid and interesting appearance, especially when its moons are arranged, two on each side, at nearly equal distances from the planet and from each other. When a magnifying power of above a hundred times is used, its surface appears much larger than the full moon does to the naked eye.* The most striking appearance on the surface

* Those who are not accustomed to view the heavenly bodies through telescopes, are apt to imagine that they are not nearly so much magnified by the instrument as they really are. With a power of one hundred times, most persons would imagine that Jupiter appeared much less than the moon to the naked eye; and yet it may be proved that such a power presents this planet to the eye with a diameter of about twice that of the apparent size of the moon. The mean apparent diameter of Jupiter is

of this planet is a series of darkish stripes, which run across its disk parallel to its equator, which are generally denominated its belts. They were first discovered by Fontana, and two other Neapolitans, about twenty-five years after the invention of the telescope. They were afterwards more particularly described by Cassini, who was enabled to view them with more powerful telescopes. Their number is variable—sometimes eight have been seen at one time, and sometimes only one or two have been distinctly visible. Their general appearance, for several years past, as viewed with telescopes magnifying from one hundred to one hundred and eighty times, is as follows :—two dark belts, one on each side of the planet's equator, and two fainter ones, one at each pole, somewhat broader than the equatorial belts. Sir James South states, that when he was making observations with his twenty-feet Achromatic telescope, with powers of 252 and 346, he perceived Jupiter "literally covered with belts." These belts, though generally parallel to each other, are not always so—for a portion of a belt has been seen in an oblique position to the rest. At certain times the belts have continued without sensible variation for six or eight months; and, according to some observers, a new belt has been formed in the course of a few hours.

It has been a subject of much speculation and conjecture among astronomers, as to the views we should entertain respecting the nature of these belts, and the causes which operate in producing the changes which occasionally take place among them. Whatever opinion we may form on this point, it is pretty evident that the dark stripes or belts are the real body of the planet, and the bright spaces between them are either clouds in its atmosphere, or circular zones, liable to variations, which surround the planet at a certain distance from

thirty-eight seconds, which, being multiplied by one hundred, the magnifying power, produces three thousand eight hundred seconds, which is equal to sixty-three and one-third minutes. Now, the mean apparent diameter of the moon is thirty-one minutes, twenty-six seconds, the double of which is sixty-two minutes, fifty-two seconds, which is less than the apparent size of Jupiter when magnified one hundred times. But, when in opposition, Jupiter's apparent diameter is forty-seven and a half seconds, and, consequently, at such a period, this planet will appear still larger. In order to produce full conviction of the accuracy of the above statements, an observer should view Jupiter, when in the immediate vicinity of the moon, and, looking with one eye through the telescope, and with the other at the moon, endeavour to make the image of Jupiter in the telescope to coincide with the moon, and he will then clearly perceive the proportion of their apparent magnitudes. From what has been now stated, it appears that a magnifying power of fifty times will make the disk of Jupiter appear as large as the moon to the naked eye.

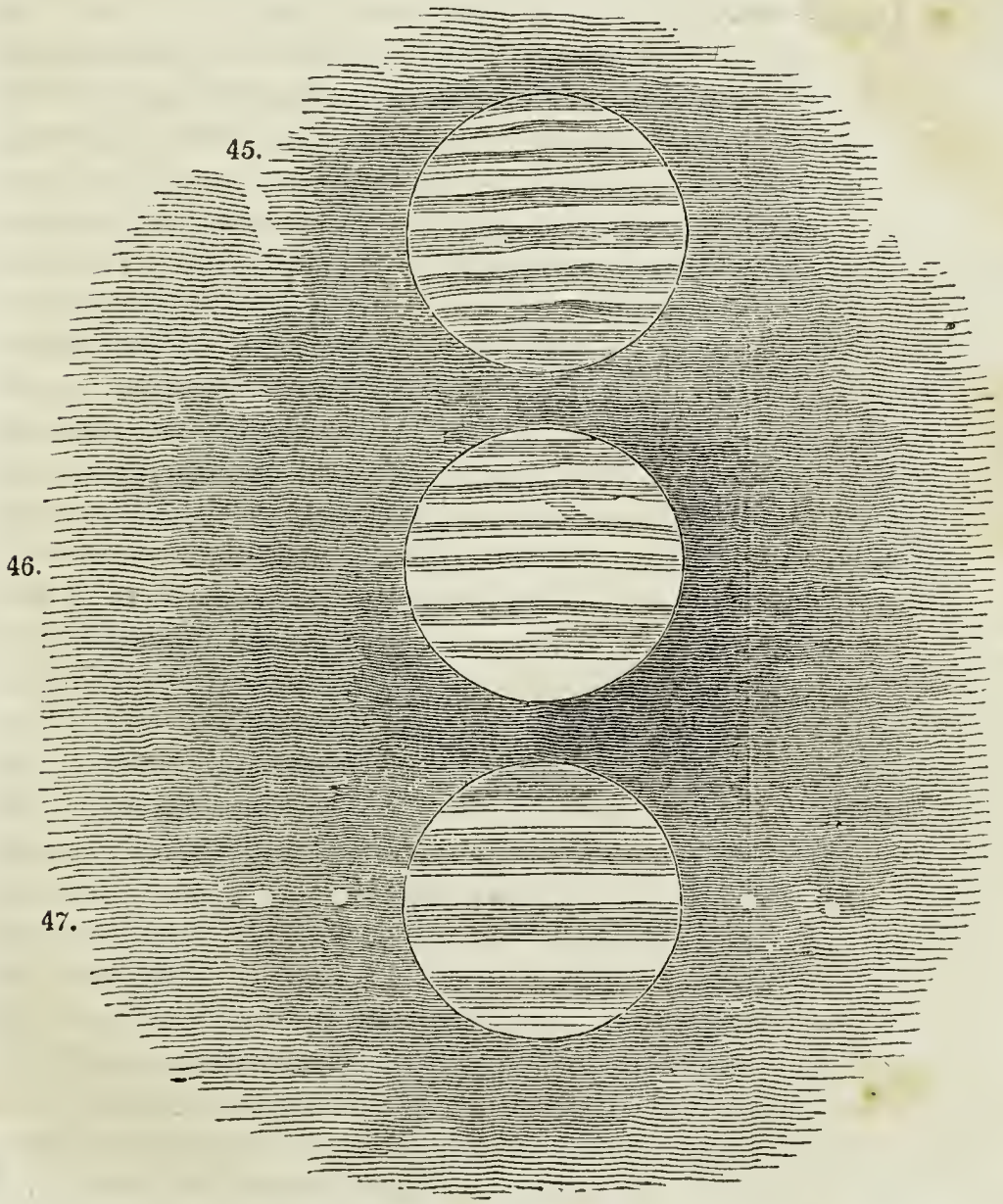
its body. Some have insinuated that the changes among these belts are owing to great physical convulsions occasionally taking place on the surface of Jupiter—an opinion altogether improbable. Others suppose that the bright streaks are the external surface of masses of clouds disposed in rows, and that such a disposition of clouds might be produced by prevailing winds blowing in a direction parallel to the equator of the planet. They have been compared to our trade-winds, which are considered as the necessary effect of the earth's diurnal rotation, combined with the influences of the solar heat upon the tropical belt of the earth; and that the rapid diurnal motion of Jupiter will cause the trade-winds in that planet to have a permanence, force, and range, which would produce a distribution and arrangement of the clouds floating in its atmosphere, such as we observe in the appearance of its belts.

This is an opinion which very generally prevails among astronomers; but we do not think that it will fully account for the phenomena of the belts, or that it is consistent with the idea of a habitable world. For if the trade-winds in Jupiter were increased, in velocity and force, twenty-seven times greater than our trade-winds—which is admitted by those who hold this opinion—then their violence would be such as to drive every thing before them along the surface of the planet, and there would be no possibility of living beings moving in opposition to such rapid currents. It is reckoned that, in a high gale, the wind moves at the rate of about thirty-eight miles an hour—multiply this number by twenty-seven, and the product, 1026, will give the velocity of a gale in Jupiter in the same time. Now, it has been found that a West India hurricane, blowing at the rate of a hundred miles an hour, has blown heavy cannon out of a battery, torn up trees by the roots, and carried huts, sheds, and human beings to a considerable distance through the air. What, then, would be the force of a gale moving at the rate of a thousand miles an hour? And, much more, what would be the force of a hurricane in Jupiter, moving at the rate of two thousand seven hundred miles an hour? On such a globe as ours, it would overturn and demolish every thing upon its surface, so that our strongest and most stately buildings could not possibly resist its force. Such a state of things appears altogether inconsistent with the idea of a comfortable habitation either for sensitive or intellectual beings. It is much more consistent with the imperfection of our knowledge, at once to acknowledge our ignorance, and to wait for future discoveries

on this subject, than to broach opinions which lead to such consequences.

The following figures represent different views of the belts of Jupiter. Fig. 45 represents one of the views taken by Cassini, in which about eight or nine belts appear, some of them somewhat broken and irregular. Fig. 46 represents another view, in which there appears an oblique belt forming a connection with two adjacent belts, as if it were a fluid running from the one into the other. Some have attempted to trace a resemblance in the changes of the belts and spots to what would appear upon the disk of the earth, viewed at such a distance as would bring it to the size of Jupiter. It is supposed that the great ocean, which environs our globe, would resemble the principal belt of Jupiter; the Mediterra-

Figures 45, 46, 47.



nean, one of the broken belts; the Caspian sea, a large spot; some of our largest islands, the bright spots seen in the belts, as in fig. 45; and the clouds, stretched round the equator of the earth, the changeable belts. But such views are more fanciful than accordant with the observed phenomena of this planet, and we must wait for further discoveries before we come to any decisive conclusions on this subject. Perhaps the Earl of Rosse's great telescope, which is now in use for celestial observations, may be the means of throwing some further light on this subject, and enable us to form more correct views of the belts, spots, and other phenomena of this planet. It has already resolved certain nebulæ into stars, which were formerly supposed to be unresolvable. Fig. 47 represents a telescopic view of Jupiter and his four satellites, when two of them happen to be on each side of his disk. The belts, as represented in this figure, are nearly similar to what they have appeared for several years past.

We may just mention the following additional particulars respecting this planet:—Notwithstanding the brilliancy with which it appears in our nocturnal sky, its light, derived from the sun, is 27 times less than what falls upon the earth; and the diameter of the sun, as seen from Jupiter, is only 6 minutes 9 seconds, or about one-fifth of the diameter the sun appears to us. The figure of this planet is that of an oblate spheroid—the equatorial being more than six thousand miles larger than the polar diameter. Its density, compared with that of water, is as 1 $\frac{1}{24}$ to 1—in other words, it is somewhat denser than water. Although it is one thousand four hundred times larger than the earth in bulk, yet it would weigh only three hundred and twelve globes of the same size and density as our globe. Its mass, as compared with that of the sun, is as 1 to 106,709. A body, weighing one pound at the equatorial surface of the earth, would, if removed to the surface of Jupiter, weigh 2 pounds, 4 ounces, 8 drams. The eccentricity of its orbit, in miles, is 23,810,000, and the inclination of its orbit to the ecliptic is 1 degree 19 minutes. In the firmament of Jupiter, no planets will be visible to such eyes as ours, excepting Saturn and Uranus. An observer, placed on this planet, would have no suspicion that such a globe as our earth had an existence in the universe—all its fancied splendours and its proud inhabitants are as much unnoticed and unknown as the smallest animalcule in a drop of water to the unassisted eye. To his satellites, Jupiter will appear as a large and resplendent moon in their firmament, filling a considerable portion of the sky; from the surface of

the first satellite it will appear above a thousand times larger than the moon does to us, and will, in succession, present to it all the diversified phases of the moon—a crescent, a gibbous phase, a half-moon, and a full enlightened hemisphere.

SEC. V.—ON THE SATELLITES OF JUPITER.

This planet is accompanied by four satellites, or moons, which revolve around it in different periods of time. The discovery of these revolving bodies was among the first enterprises accomplished after the invention of the telescope; they were first discovered by Galileo, an Italian astronomer, in the beginning of the year 1610. In his book, entitled "Sidereus Nuncius," he gives us a particular account of their discovery, and the numerous observations he made on their motions and relative positions, accompanied with sixty-four figures of their various aspects at different times. On the 7th of January, 1610, in the evening, while observing the stars with his newly-invented telescope, he perceived Jupiter making his appearance, and, applying his instrument to that planet, he perceived three small bright stars very near it, two on the east side and one on the west. These he took to be fixed stars, at that time; but, happening the next night to view them again, he saw them all three on the west side of Jupiter; which made him greatly wonder how this could be, for it was an event quite inconsistent with the theory of the planets and fixed stars. On the tenth night he saw but two, and both on the east of Jupiter; on the eleventh also he saw but two, and both on the same side; but one of these was twice as large as the other—and, hence, he was sure they were not the same he saw the night before. On the thirteenth night, viewing them again, he saw four of these small stars, three on the west side of Jupiter, and one on the east side, all nearly in a straight line. On the fifteenth, he beheld all the four on the west side of the planet, nearly in a straight line, and at equal intervals from Jupiter and from each other. These were all he could ever discover; and, by constantly observing their situation and changes, found that they were not fixed stars, but moons, or secondary planets, revolving about Jupiter in the same manner as the primary planets revolve about the sun. The telescope with which these observations were made magnified about thirty-three times.

These satellites form a system of revolving bodies, somewhat similar to the great system of the sun and primary planets. As the sun is the centre of the primary planets, so Jupiter is the immediate central body around which the

satellites revolve; but while these revolutions are going forward, the satellites are at the same time carried along with Jupiter in his course round the sun. The satellites are governed by the same laws as the primary planets; they describe equal areas in equal times; and have the squares of their periodical times proportioned to the cubes of their mean distances from the planet. They revolve from west to east, in the same direction as the moon and the primary planets—and in planes very nearly, though not exactly, coincident with the equator of the planet, or parallel to its belts. Accordingly, we see their orbits projected very nearly into straight lines, in which they appear to oscillate to and fro, sometimes passing before Jupiter, and casting shadows on his disk, and sometimes disappearing behind his body, or being eclipsed by his shadow at a distance from it. It has been established, from observation, that 247 revolutions of the first satellite, 123 revolutions of the second satellite, and 61 of the third satellite, are performed exactly in the same number of days. It has been found, by La Place, that "the epoch (or mean longitude) of the first satellite, minus three times that of the second, plus two times that of the third, is exactly equal to a semicircle, or 180 degrees." From this it follows, that the first three satellites of Jupiter can never be eclipsed at the same time; for, if this were possible, the longitude of three satellites would be equal at the time of their eclipse, which is impossible.

These satellites suffer numerous eclipses in their revolutions round Jupiter. The first three suffer an eclipse every time they are in opposition to the sun. The first is in opposition every forty-two and a half hours, and consequently suffers about eighteen eclipses every month. The second and third likewise suffer a variety of eclipses every month; but the fourth satellite frequently passes its opposition without being involved in the shadow of Jupiter, as its orbit has a greater degree of inclination to the orbit of Jupiter, than those of the other satellites. During the year 1845, there happened 174 visible eclipses of the first satellite, 88 of the second, and 45 of the third—besides those which are invisible on account of Jupiter's nearness to the sun. Whereas the fourth satellite did not suffer a single eclipse during the year 1846. These satellites may be seen with a telescope magnifying about twenty-five or thirty times; but, in order to see their eclipses to advantage, the telescope should be furnished with powers of 100 or 200 times. The circumstances to be chiefly observed, in reference to the satellites, are, their

eclipses—that is, their entering into the shadow of Jupiter, when they suddenly disappear, or their emersion from it; their occultations or disappearance behind the body of the planet; their transits or passage across its disk; and the transits of their shadows across the face of Jupiter, which appear like dark spots on a bright ground—all which phenomena may be perceived by means of powerful telescopes. When they pass across the disk of Jupiter, and project a shadow on his surface, this produces a solar eclipse to all those places over which the shadow passes.

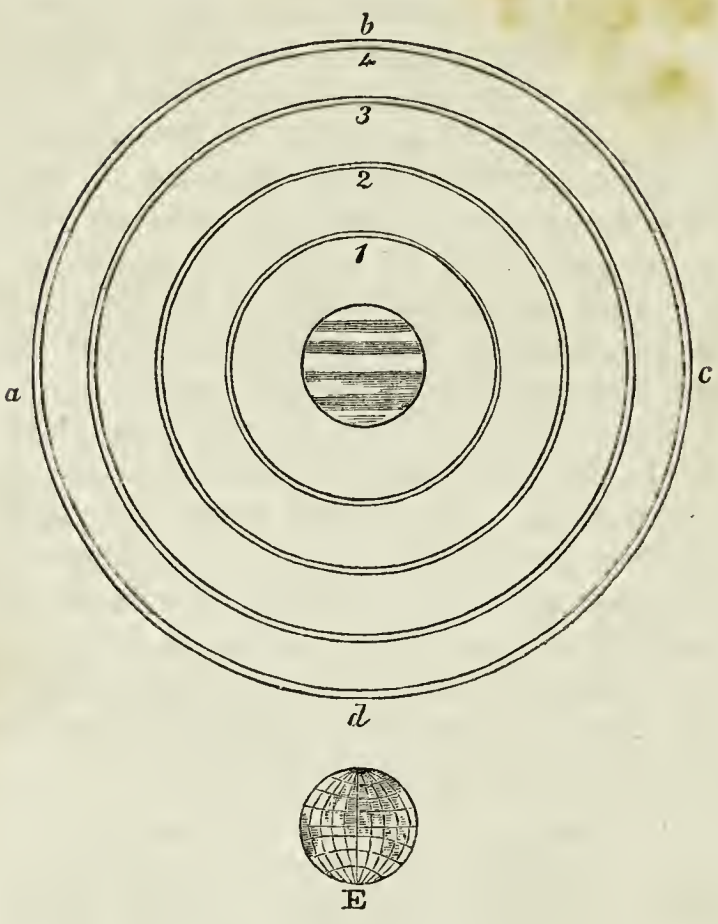
It has been concluded, from observations made by Sir W. Herschel and others, that the satellites of Jupiter always turn the same face to the planet, and make one rotation on their axis during one revolution round the planet—which corresponds with what we find in the case of our moon, which, as formerly noticed, always turns the same hemisphere to the earth. The following table shows the magnitudes of these bodies, their times of revolution, their distances from Jupiter in miles, and the duration of their eclipses:—

	Diameter in Miles.	Dist. from Jupiter.	Times of Revolution.	Duration of Eclipse.
1st satellite,	2,508	260,000	1d. 18h. 28min.	2 hours.
2d	2,068	420,000	3 13 14½	3
3d	3,377	670,000	7 3 43	3½
4th	2,890	1,180,000	16 16 32	5

The fourth satellite is about three times the bulk of our moon, and all the satellites taken together are equal to nearly thirteen of our moons. The number of square miles on the surfaces of all the satellites is above ninety-five millions. Fig. 48 shows the orbits of the four satellites, though not in the exact proportion of their distances from Jupiter—the fourth satellite being nearly double the distance of the third. When a satellite moves through the part of its orbit, *a b c*, which is farthest distant from the earth—which is supposed to be placed in the direction E—it appears to move from west to east; but when it moves through the other portion of its orbit, *c d a*, it appears to move from east to west. But, as our eye is nearly on a level with the plane of the orbits of these satellites, their motions appear to be performed nearly in straight lines. Though their enlightened sides are almost constantly turned towards the earth, yet they present all the varied phases of the moon to Jupiter himself—sometimes appearing as crescents, sometimes as half-moons, and sometimes shining with full enlightened hemispheres.

The eclipses of these satellites have been found of great

Figure 48.



utility in determining the longitude of places on the surface of our globe, in a manner much more accurate and easy than was known prior to their discovery. They also led to the discovery of a sublime and unexpected fact, namely, the motion of light, and the rate at which it is propagated through the regions of space. It was found that a difference of sixteen and a half minutes existed between the times when the eclipses were seen when Jupiter was nearest the earth, and when he was farthest distant; and it was concluded that light requires this space of time to fly across the earth's orbit, which is one hundred and ninety millions of miles in diameter, and, consequently, that light moves with a velocity of about one hundred and ninety-two thousand miles every second. This conclusion has been fully confirmed by Dr. Bradley's discovery of the aberration of the light of the fixed stars.

The four moons, which accompany this planet, must exhibit many curious and sublime phenomena to its inhabitants, as they perform their nocturnal courses through their firmament. Sometimes they will be seen eclipsing the sun, and, at other times, the stars, and sometimes eclipsing each other. Sometimes two, three, and even all the four will be seen

shining in the heavens in one bright assemblage—one, perhaps, in the form of a crescent; one with a gibbous phase; one like a half-moon; and the other with a full enlightened hemisphere; one moving comparatively slow, and another rushing rapidly through the sky, and leaving all the others behind it; one under a total eclipse, another entering into it, and a third emerging from it. These, and many other celestial phenomena, must be highly interesting and gratifying to the astronomers and all others in that far distant world. The celestial scenes exhibited from the satellites themselves will be no less interesting and sublime. From the surface of the first satellite, the globe of Jupiter will appear like an immense body in the firmament, above a thousand times the size that the moon appears to us, and filling a large portion of the sky; and it will exhibit, in the course of twenty-one hours, a crescent, a half-moon, a gibbous phase, and a full enlightened hemisphere, with all the variations of the belts which diversify its surface. Besides, the appearances of the other three moons in its firmament will be highly interesting. At certain times, one of these moons will come so near the first satellite as to appear three times larger than the moon does to us, and, at other times, it will appear sixteen times smaller than in its former position; and a variety of other phenomena will be presented, which it would be too tedious to describe—all which will present to view objects of overpowering grandeur, far superior to what we behold in our nocturnal sky.

On the whole, the planet Jupiter, as accompanied with his satellites, presents to our view an object of surpassing grandeur and sublimity, when we contemplate the vast magnitude of this magnificent globe, and the velocity with which it flies through the regions of space. Let us conceive, if we are able, a globe, fourteen hundred times the size of our world, with a surface capable of containing a number of inhabitants, eight thousand times greater than the present population of our globe; let us conceive such a globe revolving round its axis at the rate of four hundred and sixty miles in a minute, and flying through the regions of the heavens at the rate of nearly thirty thousand miles every hour, carrying along with it four revolving worlds in its swift career, and continuing this rapid course, without intermission, from one century to another, for thousands of years—and we behold a scene, calculated to fill every reflecting mind with admiration and astonishment. While contemplating such a scene, can we forbear raising our thoughts to that Almighty Being, who at first formed this mighty globe, and launched it from his pow-

erful arm, and whose incessant energy sustains it in its swift career from age to age? Here we behold a demonstrative proof that "power belongeth unto God;" that "his greatness is unsearchable;" that "all nations before him are as nothing;" that there is none like unto Jehovah, nor any works like unto his works; that He "doth great things, and unsearchable," and "marvellous things without number." And here we have palpable evidence to confirm our belief that there can be nothing beyond the power of Jehovah to accomplish, and that we may rest secure that all the promises and predictions of his word shall, in due time, be fully accomplished, to the eternal happiness of all those who put their trust in Him: "For the Lord God omnipotent reigneth, his kingdom ruleth over all;" and his faithfulness is established "in the very heavens."

SEC. VI.—ON THE PLANET SATURN.

This planet is situate at nearly double the distance from the sun as the planet Jupiter—an immense interval of 410 millions of miles intervening between the orbits of these planets, although next to each other in the order of the system. Its distance from the sun has been estimated at 906 millions of miles; when nearest to the earth, it is 811 millions of miles distant from us; and, when most remote, it is distant above a thousand millions of miles. It takes nearly thirty years to perform its revolution round the sun—during which period it moves round a circumference of nearly five thousand seven hundred millions of miles, at the rate of twenty-two thousand miles every hour. Its period of rotation was, for a long time, unknown; but Sir W. Herschel, from observing the motion of some spots on its surface, at length ascertained that it turned round its axis in the space of ten hours, sixteen minutes, and nineteen seconds.

When viewed by the naked eye, this planet presents the appearance of a nebulous star, of a dull leaden colour, which would lead one, at first sight, to imagine that it could present no very interesting appearance, even through a telescope; and, as its motion is slow, it is hardly distinguishable from a fixed star. Its motion being slow compared with that of most of the other planets—if it be once recognised in the heavens, by any observer, near any large star, it will be found, from year to year, making only a slow progress to the eastward from that point. Its apparent motion in that direction, in the course of a year, is little more than twelve degrees, or less

than the moon moves in twenty-four hours. Hence, if we perceive this planet in any particular point of the heavens this year, about the same time next year it will appear only about twelve degrees farther to the east. In the year 1846, Saturn might be seen rising on the 5th of July, about 10 o'clock in the evening, in north latitude 52 degrees, near the south-eastern part of the sky; and in 1847, about twelve days later, or about the 17th of July, he might be seen rising at the same hour, nearly in the same point of the horizon: thus the time of his appearance in the evening, from year to year, may be readily traced by any common observer.

Notwithstanding the dull appearance of this planet to the naked eye, when viewed through a powerful telescope, it presents a more singular and magnificent appearance than any other body connected with the solar system; and were it as near us as Mars, or even as Jupiter, it would present a splendid aspect even to the naked eye. The ancients, who first traced the motion of this planet, could form no idea of the grandeur of Saturn, and of the system with which it is connected; and their astrologers, on account of his pale, leaden hue, accounted him as a cheerless, unfortunate planet, and as shedding a malign influence upon the inhabitants of the earth. But after ages of darkness and superstition had rolled away, the telescope, which has unfolded to us the wonders of the heavens, was invented, and, by the help of this noble instrument, a system of revolving bodies was discovered around this planet, and a piece of celestial mechanism disclosed to view, more wonderful and magnificent than any other object within the limits of our system—the existence of which we could never previously have anticipated.

In magnitude, this planet nearly approximates to the size of Jupiter. Its diameter is estimated at seventy-nine thousand miles; its surface contains nineteen thousand six hundred millions of square miles; and its solid contents amount to two hundred and sixty-one billions, three hundred thousand millions of cubical miles. It is, consequently, nearly a thousand times larger than our globe. With powerful telescopes, four or five belts have been discovered on its surface, which are broader and less strongly marked than those of Jupiter, and are not subject to the variations which appear in Jupiter's belts—and therefore it is probable that they form permanent portions of the globe of Saturn, indicating that there is a diversity of surface on this planet; but whether land and water, or any other substance, is to us unknown. Its figure, like that of Jupiter, is a spheroid—the proportion

of the polar and equatorial diameters being nearly as eleven to twelve; consequently the equatorial diameter is 6700 miles longer than the polar. The quantity of light it receives from the sun is only the one-ninetieth part of what we receive; but this portion of light is equal in effect to the light which would be reflected from a thousand full moons of the size of that which is connected with our world. The density of this planet is less than that of any other planet in the system. It has been calculated, on physical principles, that a ball of cork equal in size to Saturn would nearly counterpoise it, that is, would be nearly of the same weight; so that its specific gravity is less than half the weight of water. Notwithstanding, it is possible that the density of the materials on its surface may be as great as those substances which form the upper crust of our globe; and its density, instead of increasing towards the centre, as is the case with the earth, may gradually decrease from its surface to its central parts, so that the materials near the centre may be as light as air.

The satellites of Saturn.—This planet is accompanied with a more numerous train of attendants than any of the other planets. No fewer than seven large moons have been discovered moving around this mighty orb to diffuse light over its surface in the absence of the sun, and to diversify the scenery of its firmament. It was nearly half a century after the invention of the telescope, before any of these satellites were discovered. The first of these bodies which was discovered was that which is the sixth in the order of distances from Saturn. It was discovered on the 25th of March, 1655, by Huygens, a celebrated Dutch astronomer. In his work, entitled "Systema Saturnium," published in 1659, he gives us an account of sixty observations—each accompanied with a figure—which he made on the various positions of this satellite in respect to Saturn, in order to determine that it was a revolving body which performed a circuit around Saturn as a centre. These observations were made with a common refracting telescope, twelve feet long, which magnified about sixty-eight times, but had not power nor light sufficient to show the rest of the satellites. It was not till the year 1671, that any other satellite was discovered: in that year Cassini, a French astronomer, discovered the seventh satellite, or the most distant from Saturn, which is next in brightness to the sixth; and in 1672, the same observer discovered the fifth satellite. Fourteen years afterwards, namely in 1686, he discovered the third and fourth; and in making these observations he used telescopes of more than a hundred feet in

length: though he tells us that afterwards he could see all the five satellites with a telescope only thirty-four feet long, which could bear a magnifying power of only about one hundred and twenty times.* No other satellites were discovered till more than a century afterwards; when Sir W. Herschel erected at Slough, near Windsor, his large forty-feet reflecting telescope. On the first day this telescope was fit for observation, namely on the 28th of August, 1789, the second satellite was discovered; and soon after, the same unwearied observer discovered the first, by means of the same instrument. These satellites cannot all be seen but by means of powerful instruments. The sixth and seventh, or the two outermost, may be perceived by telescopes magnifying from eighty to one hundred times; but the two innermost, discovered by Herschel, are the most difficult objects to be perceived throughout the whole range of the solar system, and have seldom or never been seen with a less instrument than a twenty-feet reflector, and eighteen inches aperture. It has been remarked, that the seventh satellite, or the most distant from Saturn, is sometimes not visible in the eastern part of its orbit, and that it appears to grow dimmer and dimmer as it recedes from its primary. This has been accounted for by supposing that it is sometimes covered with spots, and at other times free of them, or, if the spots be permanent, that it has a rotation round its own axis. The following are the periods of the sidereal revolutions of these satellites, and their distance from Saturn in miles. The first satellite, or that nearest to Saturn, performs its revolution in twenty-two hours and a half, at the distance of 120,000 miles from the centre of the planet, and only 18,000 miles from the edge of the ring. Of course, this satellite will move round the visible hemisphere of Saturn's firmament in little more than eleven hours. The second satellite revolves round the planet in one day and about nine hours, at the distance of 150,000 miles. The third satellite performs its revolution in one day twenty-one hours and a quarter, at the distance of 190,000 miles. These three satellites are all much nearer to Saturn than our moon is to the earth; and as they are undoubtedly larger than our moon, they must present a large and splendid appearance to the inhabitants of Saturn. The

* The long telescopes here alluded to—which were very difficult to manage, and required great dexterity and address in using them—are now entirely superseded by the invention of achromatic and reflecting telescopes, which will bear a high power, with a comparatively short length of tube; an achromatic telescope, 5 feet long, may carry a magnifying power superior to that of a common refracting telescope a hundred feet in length.

fourth satellite completes its circuit in two days, seventeen hours and three quarters, at the distance of 243,000 miles, or a little more than the distance between the earth and moon. The fifth satellite finishes its periodical revolution in four days, twelve hours, fifty-five minutes, at the distance of 340,000 miles. The sixth requires a period of fifteen days, and twenty-two hours and three quarters, and revolves at the distance of 788,000 miles. The seventh, or outermost satellite, requires seventy-nine days and about eight hours to complete its revolution, and its orbit is 2,297,000 miles from the centre of Saturn, or more than nine times the distance between the earth and the moon. The orbits of the six interior satellites are nearly circular, and very nearly in the plane of the ring. The orbit of the seventh approaches nearer in coincidence with the ecliptic.

These satellites, like those of Jupiter, undergo frequent eclipses ; but on account of their great distance from the earth, these eclipses are not frequently observed. It is evident that such a numerous assemblage of moons revolving around this planet at different distances and in different periods of time, will present a most beautiful, variegated, and sublime appearance in the heavens of Saturn; especially when all the seven satellites happen to appear at the same time above the horizon. Then one will appear as a full moon, another as a crescent, and another with a half moon, or a gibbous phase—one entering into an eclipse, and another emerging from it—the two inner satellites, on account of their nearness to the planet, presenting the largest disks, and the most splendid appearance, and moving with great velocity in their orbits, rapidly passing the other satellites, at different rates of motion, and leaving them behind in their courses. On the surface of Saturn itself, a curious effect will be produced, and a diversified scene presented. The shadows of all objects will be projected in different directions by the different satellites, according to their relative positions in the heavens. One satellite will project the shadow of an elevated object towards the east, another will project it towards the west ; a third will make it fall towards the north ; and in a variety of other directions, according to the number of satellites above the horizon, and the positions they occupy in the firmament; and the swift motion of the first two satellites will cause the direction of these shadows rapidly to change. In addition to all this variety of celestial scenery there is the grand spectacle produced by the magnificent rings with which the planet is encircled—which we will now endeavour to describe.

SEC. VII.—ON THE RINGS OF SATURN.

These rings form one of the most wonderful objects connected with the solar system. Galileo, soon after he had presented his newly-invented telescope to the heavens, was the first of mortals who caught a glimpse of this singular appendage to the globe of Saturn: but on account of the want of sufficient power in his telescope, he did not recognise the nature of the object he was contemplating. From what he could discern, he imagined that Saturn consisted of three globes—a larger globe in the middle, and two small globes, one on each side, and all the three nearly touching each other. After viewing this phenomenon for the space of two years, he was amazed, at the end of this period, to find the middle globe left quite alone, and the two smaller globes to have disappeared; but after a period of about a year he again caught a glimpse of them, when they continued visible for about fourteen years in succession. Nearly half a century elapsed before the true nature and form of this extraordinary phenomenon were discovered. During this period many were the strange conjectures which were formed respecting it. Some astronomers thought that the two small globes stuck to the middle globe, others that they were separated from it. Some thought that the phenomenon consisted of one longish body, or ellipsoid, and that it was perforated with a very large hole, or opening on each side. Some imagined that two bodies, each of the form of a crescent, were connected with the body of Saturn, and one placed on each side; and some that the phenomenon consisted of an elliptical ring, but that this ring was attached to the globe of Saturn, above and below. Huygens, in his "Systema Saturnium," presents us with fourteen engravings of the various forms which different astronomers had conceived respecting this appendage to the globe of Saturn, some of which are very curious, and almost ridiculous, yet, in some cases, indicating considerable ingenuity of conception. It was not till about the years 1655 and 1656—forty-six years after the invention of the telescope—that the real nature and figure of this singular phenomenon were discovered by Huygens. This ingenious mathematician and astronomer, in order to settle the disputes on this subject, resolved, in the first place, to improve the art of grinding object-glasses, so as to increase the magnifying power of telescopes; and in this he succeeded so far as to make some that magnified two or three times more than those which had been previously in use. With a telescope twelve feet long,

and another, twenty-three feet in length—which would magnify nearly a hundred times—and, after a long series of observations, he demonstrated the true cause of those surprising phenomena, which had puzzled all preceding astronomers, and showed to a certainty that Saturn is surrounded with an immense ring, which is entirely separated from its body by an interval of many thousand miles, and that the diameter of the ring, in proportion to the diameter of the planet, was as 9 to 4.

Since the time of Huygens, it has been discovered that this circular arch, which surrounds Saturn, is composed of two concentric rings, separated by an interval of nearly two thousand miles. The following are the dimensions of these rings, as calculated by Sir J. Herschel, from the measurements of Professor Struve, made at Dorpat—by means of the superb micrometer attached to his great telescope :—Exterior diameter of the exterior ring, 176,418 miles; interior diameter of ditto, 155,272. Exterior diameter of the interior ring, 151,690; interior diameter of ditto, 117,339. Equatorial diameter of the body of Saturn, 79,160. Interval between the planet and the interior ring, 19,090. Interval between the two rings, 1791. Thickness of the rings, 100 miles. These dimensions are considered by some as rather too small. Sir W. Herschel, and all the astronomers who preceded him, estimated the exterior diameter of the exterior ring as above two hundred thousand miles; and Sir John Herschel himself admits, that "the interval of the rings above stated is possibly too small." Still the dimensions here stated convey to us a most astonishing idea of the magnitude and grandeur of those magnificent rings which encompass the globe of Saturn. Sir W. Herschel, by means of several protuberant points connected with the ring, discovered that it has a swift rotation around the globe of Saturn, which it accomplishes in about ten hours and a half—which, reckoning its circumference, according to the lowest dimensions, at 554,234 miles, is a velocity of about nine hundred miles every minute.

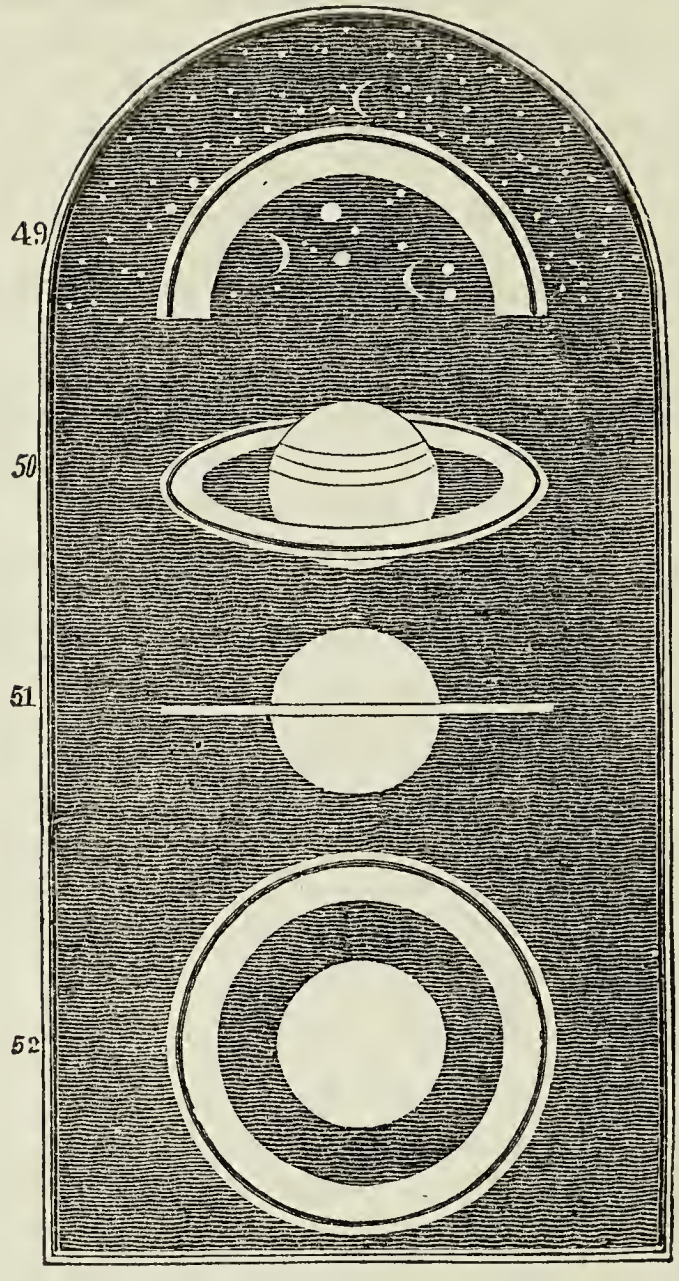
This double ring is evidently a solid body, as appears by its throwing a well-defined shadow upon the body of the planet, on the side nearest the sun, and on the other side receiving the shadow of the planet itself,—which is seen, at certain times, by means of powerful telescopes. It is everywhere at least twenty thousand miles distant from the surface of the planet, and yet it is carried along with it in its annual revolution round the sun; and, therefore, if it were not a solid body, it would either fly off from Saturn, or its centrifu-

gal force, caused by its rapid rotation, would dissipate all its parts, and disperse them around the body of the planet. These rings contain, on all their surfaces taken together, an area of more than twenty thousand millions of square miles, which is more than a hundred times the area of our globe. They, therefore, contain ample space for the accommodation of thousands of millions of inhabitants.

In consequence of the immense size of these rings, and the large space they will occupy in the heavens, they will present a magnificent spectacle from those regions of the planet which lie under their enlightened sides, particularly those places which are situated not far from the planet's equator. They will appear as vast arches, spanning the firmament from one part of the horizon to the opposite, and holding an invariable situation among the stars. They will not be visible at the poles of the planet, on account of the convexity of the globe of Saturn interposing between them and the observer; but, near the polar regions, a segment of the rings will appear, presenting a brilliant appearance in the horizon. Advancing from these regions towards the equator, they will appear to span the heavens, like brilliant arches of different degrees of magnitude, till, approaching near the equator, they will appear in the form of complete semicircles. Fig. 49 presents a rude sketch of the rings, as they will appear from such a position, together with a partial view of the nocturnal firmament of Saturn. But no pictorial representation, however ample the scale, can convey even an approximate idea of the august and splendid objects which must diversify and adorn the nocturnal sky of Saturn. For, besides the rings, which will form the most striking and magnificent spectacle, there are seven moons, three or four of which generally diversify the celestial hemisphere, appearing in different positions, and with different phases; and, sometimes, the whole seven satellites may be beheld in one bright assemblage, pursuing their different courses among the stars, and rapidly shifting their positions and aspects.

The views of Saturn and the rings, obtained by powerful telescopes, are highly interesting and beautiful; but the appearance of the rings is not the same at all times. When seen to the greatest advantage, they appear as represented in fig. 50, where they assume the appearance of ellipses, or ovals, with the planet in the centre, and on each side of the planet the dark space or interval between the interior ring and Saturn. The division between the rings is indicated by a dark line which seems to go round the ring, which is the

Figures 49, 50, 51, 52.



empty space by which they are separated. It is only about once in 15 years, however, that the rings appear so open as here represented; and sometimes they are altogether invisible as seen from the earth. This happened in October, 1832; and after being visible for some time, from December, 1832, to April, 1833, the ring again disappeared for two or three months. During this time, the only indication which was given of its existence was the shadow of the ring, which appeared like a dark belt across the body of the planet. At present, (1846,) the rings appear much narrower than what is represented in the figure, though the dark space between the planet and the ring is distinctly visible. In 1847, the ring will appear still narrower—in the beginning of that year, it

will appear nearly as in fig. 51, like a line of light on each side of the planet, but without any apparent opening of the ring; in the beginning of 1848, it will entirely disappear, and, in this case, the thin edge of the ring is turned towards the earth, and the planet appears as if it were entirely divested of its magnificent appendage, and to move solitary among the stars. About July or August, of the same year, the ring will again appear, through good telescopes, as a fine thread, or line of light, on each side of the planet; and, in 1849, the opening of the ring and the dark space between it and the planet, will be distinctly visible. During the years 1850 and 1851, the ring will appear still more expanded, till towards the end of 1854, when it will appear fully expanded, as in fig. 50; and, during the other seven years and a half, it will gradually contract till about the end of 1861, or the middle of 1862, when it will again become invisible.

The phenomenon of the disappearance of the ring takes place at intervals of 14 years and 9 months, and happens when the planet is in 170 degrees, and 350 degrees of longitude, or in the 20th degree of Virgo, and the 20th degree of Pisces. The sun shines on the one side of this ring during a period of nearly 15 years, and the regions of the planet, that lie under the dark side, suffer a solar eclipse, under its shadow, during the same period. But there is no doubt that this apparent defect is compensated, not only by the light of the satellites, but by other arrangements, with which we are unacquainted. This planet, with its rings, would exhibit a more splendid and interesting appearance through our telescopes, could we view the rings, not obliquely, but as standing at right angles to our line of vision, as represented in fig. 52. This represents the real position of the rings in respect to the planet; but our eye is never so much elevated above the plane of the rings as to view them in this manner; it is never elevated more than 30 degrees above the planes of the rings, so that we never see the rings more fully expanded than what is represented in fig. 50.

Had our limits permitted, we might have inquired into the ends for which these rings were formed by the Almighty Architect, and the designs they are intended to accomplish in the system of Saturn. But, in consequence of the great distance at which we are placed from this planet, and of our ignorance of many of the plans of the great Creator in his arrangements of the universe, we are unable fully to appreciate all the designs he intended to accomplish, either in this, or in other parts of his operations. There is one object, how-

ever, that these rings were evidently intended to accomplish; namely, to throw a light on the regions of the planet in the absence of the sun—to serve the purpose of a thousand moons—to produce a diversified and sublime scenery in the nocturnal sky of Saturn, and to display the glory and magnificence of the Creator. They evidently manifest his power in the amplitude and greatness of their dimensions, in the vast quantity of matter they contain, and in the amazing rapidity with which they revolve around the planet—and his wisdom in nicely balancing and proportionating every minute circumstance in their construction and arrangement, by certain laws, so as to prevent them either from flying off from the planet in its swift career, or from falling down upon its surface, and producing a complete derangement of the whole fabric of this mighty globe—and likewise in preserving them in their exact position, and proper motions, without variation, from age to age. They may likewise be intended to teach us in what a variety of modes, inscrutable to us, the Creator may bring into existence numerous worlds, encompassed with celestial machinery and arrangements altogether different from any thing we have hitherto contemplated—which may lead us to conclude that, in other systems, and around other suns, worlds may exist diversified with celestial scenery, of which we find no traces throughout the whole range of our planetary system.

But, besides these general designs, we conceive, there is another important end these rings are intended to subserve; namely, to form a habitation for numerous orders of intellectual beings. Wherever matter exists in our world, we find it peopled with different orders of animated existence; and therefore it would be absurd to suppose that the celestial bodies—formed by the same All-wise and Almighty Being—should be altogether destitute of inhabitants. The quantity of surface on the rings is more than twenty thousand millions of square miles, being more than a hundred times the area of the whole terraqueous globe, and consequently contains ample space for the accommodation of myriads of inhabitants; and it is highly improbable, from what we know of the plans of infinite wisdom, that such a space should remain for ever as a barren desert, without contributing either to sensitive or intellectual enjoyment. The scenery of the heavens, as beheld from the rings, would even be more grand and diversified than that which is beheld from the surface of Saturn, and would afford to intelligent natures a striking display of the perfections of their Creator.

We may just farther state, in relation to this planet, that several late astronomers are of opinion that the outer ring of Saturn is divided into several smaller rings. Captain Kater states, in a paper sent to the "Astronomical Society," that on December 17th, 1825, with a reflecting telescope of six feet six inches focus, "he saw the outer ring of Saturn, separated by numerous divisions, extremely close, one stronger than the rest, dividing the ring about equally. Professor Quetelet, at Paris, likewise states, that, with the achromatic telescope of ten inches aperture, "he saw the outer ring divided;" and Decuppis, at Rome, is also said to have observed the same phenomenon. Mr. Lawson, an ingenious astronomer, at Bath, who has lately erected a splendid achromatic telescope, twelve feet long, states, that with some of its higher powers, he has several times observed several divisions on the ring of Saturn. If this magnificent arch is not merely double, but even treble, or quadruple, it presents a still more wonderful idea to the mind, especially if each of the rings have a distinct and separate rotation round the planet. But as the divisions alluded to have not been perceived by other observers in the most favourable circumstances, we must suspend our opinion on this point, till more minute and extensive observations be made, either to disprove or to confirm those which we have now stated.

In concluding our reflections on this planet, it is almost needless to remark, that the planet itself, with all the celestial scenes connected with it, presents to the mind an object of surpassing grandeur and sublimity. Let us suppose ourselves stationed within a few thousand miles of this planet—a station which some superior intelligences may occasionally occupy—from such a position, the globe of Saturn, the rings, and the satellites, would appear to fill the greater portion of the visible heavens. Let us then conceive this planet—a thousand times larger than the earth—flying before us at the rate of twenty-two thousand miles an hour, carrying along with it stupendous rings, five hundred thousand miles in circumference, and these rings revolving round the planet with a velocity of nine hundred miles every minute, and seven other spacious globes, larger than our moon, wheeling their rapid courses, at different distances around the planet and its rings—let us endeavour to stretch our imagination to the utmost, to represent such a scene as nearly as possible to the reality, and suppose ourselves as spectators—how grand and overwhelming, and almost terrific, would be the amazing spectacle! Amidst the emotions it would excite, we could only exclaim

"GREAT AND MARVELLOUS ARE THY WORKS, LORD GOD ALMIGHTY!"—"Thy right hand, O Lord, is become glorious in power!"—"Who can utter the mighty acts of the Lord!"—"The Lord God Omnipotent reigneth!" Is it possible to separate such scenes and operations from the idea of an eternal and Almighty intelligence, who formed, and arranged, and set in motion, such stupendous machinery? Could chance, or the fortuitous concourse of atoms, have ever produced such a portion of celestial mechanism, and preserved it unimpaired in all its relations and movements, from age to age? Such an idea is fraught with the grossest absurdity that ever entered the human imagination. If a Divine superintendent over creation did not exist, the whole frame of universal nature would long ere now have been unhinged, and the universe, with all its splendid orbs and mighty movements have been transformed into a chaos, and scattered throughout the regions of infinitude. And, "since a God there is, that God how great!" His power is irresistible, his wisdom is unsearchable, and his agency pervades the immensity of space. To refuse to submit to his laws and his moral government must, therefore, expose us to the most dismal consequences. For thousands of means are within the range of his wisdom and intelligence by which the rebels against his authority may be arrested and punished; and his power to execute his purposes no created beings can control. "The mountains quake at him, and the hills melt, and the earth is burned at his presence. Who can stand before his indignation?" "The pillars of heaven tremble and are astonished at his reproof." Happy they who have this Almighty Being as their father and their friend, "who do his commandments, hearkening unto the voice of his word." For all the glories of creation, and all the resources of the universe are at his disposal to contribute to their knowledge and felicity, while ages numerous as the drops of ocean are rolling on.

SEC. VIII.—ON THE PLANET URANUS.

Till near the close of the last century, Saturn was considered as the remotest planet from the sun, and his orbit as forming the outermost boundary of the planetary system. But, since the discovery of Uranus, the diameter of the system is doubled, and the area of the space it comprehends is four times the dimensions formerly supposed. Instead of an area of twenty-five thousand millions of square miles—its former supposed dimensions—it now comprehends at least one hundred thousand millions of square miles; throughout

every portion of which the influence of the great central luminary extends, and likewise as far beyond as the erratic comet pursues its distant course. It is somewhat strange that, from the time of Huygens and Cassini, when telescopes were brought to a certain degree of perfection, till near the close of the eighteenth century, (a period of more than a hundred years,) no new discoveries were made in the heavens, when the number of those who cultivated the science of astronomy was increased, and the science itself had received many improvements. But the mind of man has a propensity to indolence when not stimulated by worldly gain, and certain difficulties to be encountered tend to discourage and impede its progress. The long and unwieldy telescopes used by the astronomers of the seventeenth century were very difficult to manage, and required long exposure to the cold air of the evening, and their attention was chiefly directed to observations on the planetary bodies which were then known. Few observations, comparatively, were made on the fixed stars, so as to ascertain the varieties which exist among them, the changes to which they are subject, or the moving bodies that may be found in the stellar regions; and hence, in part, the reason that so few discoveries were made during that period.

The appearance of the late Sir William Herschel, as an observer of the heavens, formed a new era in the history of astronomy. This illustrious astronomer having viewed the heavens with a two-feet Gregorian telescope, which he had borrowed, was so much interested with the instrument, that he commissioned a friend in London to purchase for him one of a larger size. The price, however, being more than he anticipated, and more than he could afford, he resolved to attempt the construction of one with his own hands; and in this he succeeded. A five-feet Newtonian reflector, which he completed in 1774, was the commencement of that brilliant series of discoveries and improvements which he afterwards effected. While residing in Bath, he had been engaged for a year and a half in making a regular survey of the heavens, when on the evening of the 13th of March, 1781, he discovered, among other stars, one of unusually steady radiance; continuing to watch it, he found, after several observations, a perceptible change in its position, although its motion with relation to the other stars was very slow. Having sent an account of this observation to Dr. Maskelyne, the astronomer royal, it was at first supposed to be a comet, but soon afterwards it was ascertained beyond a doubt that it was a new

planet which had, in all former ages, eluded the observation of astronomers. For this discovery the Royal Society conferred upon Herschel the honorary recompense of Sir Godfrey Copley's medal; and he named the planet Georgium Sidus, in honour of his majesty king George the Third: but the continental astronomers distinguished it by the name of Herschel, in honour of the discoverer; and it is now more generally known by the name of Uranus. Soon after this discovery, Herschel was taken under the patronage of his majesty, and rewarded with a pension of £300 per annum. He removed to Slough near Windsor, where, in 1789, he erected his large forty-feet telescope, by which he was enabled to make further discoveries.

The planet Uranus is not visible to the naked eye, and requires a certain degree of magnifying power to render it visible as a very small star. We have seen it in this way with a power of twenty times, but it requires a power of at least two hundred times to make it appear like a well defined visible disk. Its real magnitude, however, is considerable,—being no less than thirty-five thousand miles in diameter, or more than eighty times the size of our globe. Its surface contains three thousand eight hundred and forty-eight millions of square miles,—which is seventy-eight times the area of all the habitable portions of the earth; so that this apparently small body, which had remained unnoticed for thousands of years, adds considerably to the quantity of matter formerly supposed to belong to the solar system. For it contains a mass of matter, as to bulk, more than twenty times larger than what is contained in Mercury, Venus, the Earth, the Moon, Mars, Vesta, Juno, Ceres, and Pallas. Its distance from the sun is about double that of Saturn,—being no less than eighteen hundred millions of miles. To reach the nearest point of its orbit, a cannon ball, flying from the earth in that direction, at the rate of five hundred miles an hour, would require a period of three hundred and ninety years. It moves round the sun in the space of eighty-four years, in an orbit eleven thousand millions of miles in circumference; at the rate of fifteen thousand miles an hour. The inclination of its orbit to the plane of the ecliptic, is 46 minutes, 28 seconds.

From the immense distance at which this planet is placed from the sun, we might be apt to imagine that there will be a great deficiency of light and heat on its surface. The quantity of light it receives from the sun is about three hundred and sixty times less than what the earth receives;

for the quantity of illumination enjoyed in any planet is in an inverse proportion to the square of the distance of the luminous body that enlightens it. The quantity of light on Uranus—notwithstanding its great distance from the sun—will be equal to what we should have, were three hundred and forty-eight full moons continually shining on our globe at one time. But the pupils of the eyes of the inhabitants of this planet may be so constructed as to take in ten or twenty times the quantity of light which our eyes would receive, were we placed in that distant region. And as to sensible heat, it does not appear that this depends on the distance of a planetary body from the sun; but on the nature of its atmosphere, and the substances on its surface on which the rays of light and heat fall. Every part of our globe may be considered as at an equal distance from the sun, and yet there are all the varieties of temperature experienced from twenty degrees below zero in the frozen regions of Greenland, to a hundred degrees above it, in the scorching climes of the torrid zone. On the top of the Andes, in South America, there is the most intense cold, and perpetual snows; while in the plains below excessive heat is felt under the rays of a tropical sun, while only a few miles intervene between the respective localities. At any rate, we may rest assured that, throughout all the regions of the universe, the Creator has displayed his wisdom and goodness in adapting the structure and constitution of the inhabitants to the nature of the habitation he has provided for them.

In consequence of the great distance of this planet, no discoveries have been made on its surface; no spots have been seen to indicate a rotation, and therefore the period of its revolution round its axis is unknown. But the same illustrious astronomer who first detected it, soon after discovered no less than six satellites which revolve around it. The following table contains a list of these satellites, with their distances from Uranus, and their periods of revolution.

	Period.			Distance.
1st, or nearest to Uranus.	5d.	21h.	25m.	230,000 miles.
2d.	8	17	1	298,000
3d.	10	23	3	348,000
4th.	13	10	56	399,000
5th.	38	1	48	777,000
6th.	107	16	40	1,597,708

It is somewhat remarkable, that these satellites, instead of

moving from west to east, or in the direction of all the other planets and satellites, have their orbits nearly at right angles to the ecliptic, and move in a direction from east to west. These are exceptions to the general laws of the planetary system which it is difficult to explain. But they occur at the farthest limits of the solar system, perhaps to teach us, that in other systems arrangements may exist very different from those we experience in the system to which we belong.

SEC. IX.—GENERAL REMARKS ON THE SOLAR SYSTEM.

Such is a brief description of the principal phenomena connected with the planetary bodies which compose the solar system. We have no reason, however, to conclude that all the planets belonging to our system have yet been discovered. Were a planet of double the magnitude of the Earth revolving between the orbits of Jupiter and Saturn, it would be altogether invisible to the naked eye, and might revolve for thousands of years without being observed by the inhabitants of our globe, unless astronomers were to make a minute survey, with powerful telescopes, of the whole range of the zodiac, in which most of the planets are found to move, along with portions of the celestial regions on either side of it. If the inhabitants of Jupiter and Saturn have no better eyes than ours, and no artificial helps to vision, they must be altogether ignorant that such a globe as the earth exists in the universe, nor will they ever obtain a glimpse of either Mars, Mercury, or Venus. Considering the distance that intervenes between Jupiter and Saturn, it is not at all improbable that one or more planets may exist in the interval; and since no less than 900 millions of miles intervene between the orbits of Saturn and Uranus, several planets, much larger than the earth, may revolve in those regions, which the keen eyes of astronomers have never yet detected. Even within the orbit of Mercury a planet may exist, which we may never be able to discover, on account of its nearness to the sun, being at all times immersed in the effulgence of the solar rays. Our views of the universe and its arrangements are only beginning to open and expand; but in the ages to come, if art and science still advance, objects of which we have no conception at present may be disclosed to view, even within the bounds of the planetary system.

Throughout the whole of this system we perceive *order* and *harmony* prevailing without interruption. While the planets are prosecuting their courses with amazing velocity, and moving onward in their respective spheres without

a moment's pause—while their attractive forces on each other sometimes produce slight perturbations—while one sometimes interposes between the sun and another, and casts a transient shade over its surface; yet no disorder or confusion ever occurs throughout the system: every orb finishes its respective circle of revolution in exactly the period of time in which it has been performed for thousands of years; no one ever interrupts the course of another; no satellite ever forsakes its primary, in the course of its rapid movement; but the laws of motion originally impressed upon all the bodies of the system continue to operate as they have done from the beginning. These circumstances evidently demonstrate the existence of a presiding Intelligence, who at first formed and arranged this magnificent system, and who every moment sustains it in all its movements. It would be easy to show—if this were the proper place for it—that unless an Immaterial Power continually re-excited motion in the material universe, all motion would stop in a very short time—perhaps in less than an hour—except that the planets would run out in right-lined directions; and then nothing would ensue but confusion, darkness, silence, and chaos. For matter of itself can pursue no end, obey no law, nor change the direction of its motion. If, then, a presiding Divinity is continually exerting his attributes, impressing every part of that universe to which he gave existence, we cannot deny his title to supreme dominion; and, if so, we must acknowledge that all praise, adoration, submission, and obedience are due to Him who hath created all things, and for whose "pleasure they are and were created."

It may likewise be remarked, that amidst all the varieties which characterize the planetary system, there are evident marks of unity and mutual relationship. The distances of the planets from the sun, vary from thirty-seven millions to one thousand eight hundred millions of miles. The quantity of light that falls on the surface of Mercury is two thousand four hundred times more intense than that which falls on Uranus. In point of magnitude some of the planets are several thousand times larger than others; and as to the times of their revolutions, their periods vary from eighty-eight days to eighty-four years. Some have one accompanying moon, some have four, some have seven, and others are destitute of such appendages. Yet a family likeness pervades the whole. The figure of all the planets is nearly the same; they are all either globes or spheroids; they all move round their axes, and round the same central luminary, producing

an alternate succession of day and night, and, in most instances, a variety of seasons. Most of them, if not the whole, are environed with atmospheres; and on their surfaces, mountains and plains, hills and vales, have been descried, and the law of gravitation pervades and governs the whole. One sun enlightens every member of this system, whether primary or secondary; and although this luminary appears to one planet seven times larger than to us, and to another a hundred times smaller, yet it serves all the purposes of a sun to diffuse that degree of light and splendour and benign influence which is requisite for the comfort of each respective planet. These and other circumstances plainly indicate that ONE Supreme Mind contrived this system of moving bodies, and superintends, directs, and governs the whole. For two or more supreme beings—whose plans and purposes might clash—could never be the parents of that harmony and unity of design which we perceive throughout the system of nature. Such considerations, likewise, lead us to conclude that all the planets of this system are destined to subserve in their respective spheres the same grand purposes, namely, to serve as comfortable habitations for numerous orders of sentient and intellectual beings, capable of knowing and adoring the perfections of their great Creator. For the material world could never be shown to manifest the wisdom and intelligence of its Author and Contriver, if this position were denied. For it would then exhibit only a stupendous system of means without an end, corresponding to the magnificence of the operations employed; and, in this case, there would be no extensive display of the riches of Divine beneficence.

Illustrations of the distances and magnitudes of the Planets.—Sir J. Herschel proposes the following illustration, to convey to the minds of general readers an impression of the relative distances and magnitudes of the parts of the solar system: "Choose any well-levelled field or bowling-green; on it place a globe two feet in diameter—this will represent the sun; Mercury will be represented by a grain of mustard seed, on the circumference of a circle one hundred and sixty-four feet in diameter for its orbit; Venus, a pea, on a circle of two hundred and eighty-four feet in diameter; the earth also a pea, on a circle of four hundred and thirty feet; Mars, a rather large pin's head, on a circle of six hundred and fifty-four feet; Juno, Ceres, Vesta, and Pallas, grains of sand, on orbits of from a thousand to a thousand and two hundred feet; Jupiter, a moderate-sized orange, on a circle nearly half a mile across; Saturn, a small orange, on a circle of four-fifths of a mile; and Uranus, a full-sized cherry or small plum, upon

the circumference of a circle more than a mile and a half in diameter."

From this illustration it appears, that an orrery to represent both the proportional distances and the proportional magnitudes of the sun and planets would require to be more than a mile and a half in diameter, and nearly five miles in circumference; and, in this case, scarcely any of the planets would be visible from the centre. Our common orreries and planetariums can exhibit only the relative motions of the planets, and the order in which they are placed from each other in the system; but they can present no accurate or comprehensive idea of their proportional distances or magnitudes; and the balls which represent the sun and planets being so small, and placed so near each other, have a tendency to produce erroneous conceptions. The comparative distances and the comparative magnitudes can only be separately exhibited on a small scale. The following is a simple method by which we have frequently exhibited the proportional distances of the planets. Provide a small square rod about eight feet long, at one end of which place a ball or other object to represent the sun. At two inches from the sun's ball, place a ball to represent Mercury; at three inches and a half, Venus; at five inches, the earth; at seven inches and a half, Mars; at thirteen inches, Ceres, Pallas, Juno, Vesta, almost close to each other; at twenty-five inches, Jupiter; at forty-seven inches, or about four feet, Saturn; and at eight feet, Uranus. These proportions will convey an approximate idea of the relative distances of the planets from each other and from the sun; and if wax tapers were placed instead of the balls, and lighted, these comparative distances might be exhibited to a large audience. The proportional magnitudes might likewise be exhibited as follows:—Suppose a globe of eighteen inches diameter to represent the sun, Jupiter will be represented by a ball one inch and four-fifths diameter; Saturn, one inch and two-thirds; Uranus, three-quarters of an inch; the Earth, one-sixth of an inch; Venus, one-sixth of an inch; Mars, one-eleventh of an inch; Mercury, one-fifteenth of an inch; Moon, one-twenty-fourth of an inch; Ceres, Pallas, Juno, Vesta, by small pin heads. The following numbers may assist the memory in recollecting the proportional mean distances on the planets. Suppose the distance of the Earth from the Sun to be divided into 10 parts—Mercury may then be estimated at 4 of such parts from the Sun; Venus at 7; the Earth at 10; Mars at 15; the new planets, Ceres, Vesta, etc. at 26; Jupiter at 52; Saturn at 95; and Uranus at 190 such parts.

SUMMARY VIEW OF THE SOLAR SYSTEM.

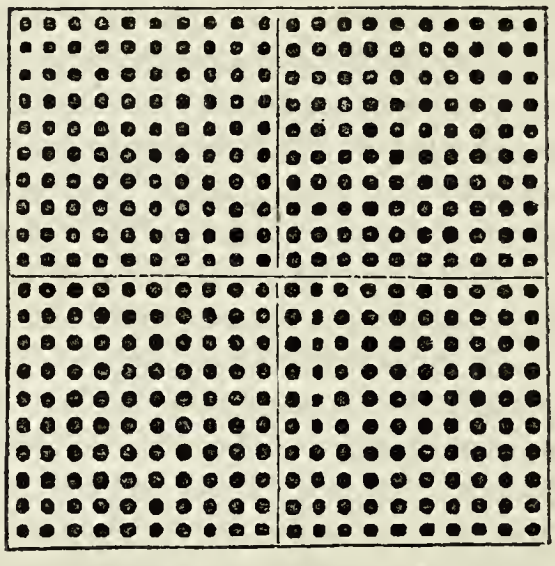
The following Table exhibits, at one view, the distances, diameters, periods of revolution, etc., of the Planets, and other permanent elements of the Solar System.

Names of the Planets.	Distances from the Sun, in Miles.	Diameters, in Miles.	Periods of Revolution round the Sun.	Rotation on Axes.	Mean angular Diameter, in Seconds, etc.	Velocity in Orbit per Minute in Miles.	Inclination of Orbits to the Ecliptic.	Inclination of Planet's Equator to the Ecliptic.	Density, that of Water being 1.	Mass, that of the Earth being 1.	Diameter of the Sun, seen from the Planets.
Sun,		880,000		25d. 10h.	32′ 3″			7° 20′	$1\frac{2}{1\frac{1}{5}}$	354936	
Mercury,	37,000,000	3,200	88 days	24h. 6m.	8″·5	1830	7°		$9\frac{1}{6}$	0·16	80′
Venus,	68,000,000	7,800	224 —	23h. 20m.	35″	1333	3° 23′		$5\frac{1}{1\frac{1}{3}}$	0·94	46′
Earth,	95,000,000	7,930	$365\frac{1}{4}$ —	23h. 56m.		1133		23° 28′	$4\frac{1}{2}$	1·	32′
Moon,	95,000,000	2,180		27d. 8h.	31′ 8″		5° 8′ 47″			0·013	32′
Mars,	145,000,000	4,200	686 —	24h. 40m.	11″	833	1° 51′	29° 30′	$3\frac{2}{7}$	0·13	21′
Vesta,	225,000,000	276	1335 —		0″·5	733	7° 8′				13′
Juno,	254,000,000	1,425	1582 —		3″	697	13° 5′				12′
Ceres,	263,000,000	1,624	1681 —		1″	683	10° 37′		2		11′
Pallas,	263,000,000	2,099	1681 —		0″·5	683	34° 37′		2		11′
Jupiter,	495,000,000	89,000	11y. 315d.	9h. 56m.	38″	500	1° 18′	3° 5′	$1\frac{1}{2\frac{4}{1}}$	338	6′
Saturn,	906,000,000	79,000	$29\frac{1}{2}$ years	10h. 16m.	16″	366	2° 29′		$0\frac{1}{3\frac{3}{2}}$	120	3′
Uranus,	1,820,000,000	35,000	84 years		4″	250	0° 46′		$0\frac{9}{1\frac{9}{0}\frac{9}{0}}$	17	1′

Method of acquiring an approximate idea of a million units.—In the preceding description of the solar system, the distances of the sun and planets, and the extent of the planetary orbits, have been expressed by millions of miles. But however accurately such distances and dimensions may be considered as stated, the mind is unable to form a distinct and comprehensive idea of such vast distances and dimensions, and even at its utmost stretch, and with all its efforts, must be contented with a very vague and indefinite conception of the immense spaces of the heavens. This is partly owing to our want of a clear and comprehensive idea of the number of units contained in a single million. We can form a clear idea of a hundred units, and even of a thousand; our ideas of ten thousand, fifty thousand, and a hundred thousand, are less clear and definite; and it is but a vague idea we generally have of ten hundred thousand, or one million, when we attempt to grasp it at one conception. We may assist our conceptions a little by such illustrations as the following:—A million of pounds would be sufficient for the formation of 5000 miles of road, at the rate of £200 for each mile—which would be sufficient to reach from the Land's End of England to the northernmost point of Scotland, to go quite round the island of Great Britain, and to cross it in different directions. The same sum would be sufficient to rear more than 666 churches, at £1500 each. It would be adequate to the building and furnishing of 2500 schools, at £400 each. Were a man to count a million sovereigns, one by one, and allow only a single second for each sovereign, and continue, without intermission, 12 hours every day, it would require more than 23 days before such a sum could be counted; and, consequently, to count in the same manner 800 millions of sovereigns, the amount of our national debt, would require more than fifty years! Were a million of men to be arranged in a straight line, similar to a line of soldiers when on parade, and three feet allowed for the breadth of every man, that line would extend over a space of more than 568 miles in length—in other words, it would extend over the whole length of the island of Great Britain, from the Straits of Dover to the Orkney Isles. Such illustrations may help to assist the mind a little in forming its conceptions of the number of units contained in a single million; to which we may add the following—that a line a million miles in length would go forty times round the circumference of the earth; and that, since the creation of the world, little more than two millions of days have elapsed.

Mr. Henry Martin, teacher, Chatham, has lately contrived a plan by which a million of units may be represented to the eye, and which produces a more striking effect than any plan hitherto adopted. It consists in the arrangement of spots of the size of those in the annexed figure. They are arranged in squares, in the manner here represented—every square containing one hundred spots. There are a hundred squares on a sheet of foolscap, which, of course, contains ten thousand spots or units; and there are one hundred of these sheets pasted on a piece of calico, which doubles up like a long map, a small space being left between each sheet, that the calico may form a hinge for doubling. The number of spots on these hundred sheets amounts to 10,000 × 100, or exactly a million. This representation of a million of units, were it to

Figure 53.



be exhibited in the most striking manner, should be stretched along the side of a large room, 8 feet high and 14 feet long, which it would completely fill; or on any surface about $10\frac{1}{2}$ feet square, and containing an area of about 108 square feet. The annexed figure contains 400 spots, which are only the $\frac{1}{2500}$th part of a million, so that it requires two thousand five hundred times the space and the number of spots contained in this figure to represent the units in a million. On beholding such a number of units or spots, as close to each other as those in the figure, and covering such a large space, the mind is struck with wonder at the number of units which a single million contains; and Mr. Martin informs me that "all persons, who have seen it, have expressed themselves much astonished at the vastness of it." Were each square, containing 100 spots, exactly of the same size as in the figure, placed

alongside each other, in a straight line, that line would extend above a thousand feet in length.

When beholding such a number of units compressed together, and yet filling so great a space, we might be apt, at first view, to consider it as a faint picture, or emblem, of immensity and eternity. But what is one million compared with hundreds and thousands of millions? That sun, which enlightens our day, is ninety-five millions of miles distant from us. The planet Uranus is one thousand eight hundred millions of miles distant from the sun, and yet is within the reach of his illuminating and attractive influence. Such immense distances are comprised even within the limits of the planetary system. How overwhelming, then, to consider the distance of the nearest stars! That distance is not less than twenty billions of miles; and let it be remembered that each billion contains no less than ten hundred thousand millions. And as to magnitudes, we are almost equally overpowered at the idea of their immensity. The sun contains, on his surface, two billions, four hundred and thirty thousand eight hundred millions of square miles; and his solid contents comprehend more than three hundred and forty-six thousand billions of cubical miles. And the sun is only one out of a hundred millions of similar globes which compose the visible universe; and, beyond all that is visible to human eyes, orbs of astonishing grandeur may exist, whose number may exceed the number of the sands that lie along the sea-shore. Hence the necessity of endeavouring to form as large and extensive an idea as possible of the number of units contained in a million, if we wish to take a comprehensive view of the immense spaces of the heavens, and the magnitude of the celestial orbs. For a million, great as this number is, forms, as it were, but a unit to thousands, tens of thousands, and hundreds of thousands of millions—to billions, trillions, and other higher numbers that sometimes enter into astronomical calculations.

What a vast and overpowering assemblage of human beings must be presented to view at that solemn day, when all the men and women, that have ever dwelt on the surface of our globe, shall appear in one great assembly before "God, the Judge of all!" The number that have already dwelt upon the earth, since the formation of the first man, is at least one hundred and forty-six thousand two hundred millions; and, probably, more than double that number may appear before that decisive day draws nigh. The idea of such an assemblage of beings is absolutely overwhelming to our limited

powers of conception. It may be proper, however, occasionally to ruminate on such subjects, as it is one of the principal modes by which we may acquire comprehensive views of the vast extent of creation, and of the ineffable glory and magnificence of the great Creator.

CHAPTER V.

ON COMETS.

Besides the planetary bodies described in the preceding chapters, there is a class of celestial bodies, considered as connected with the solar system, which have obtained the name of comets. The word comet is derived from the Greek κομη, and the Latin *coma*, both which signify the hair, and a comet was so denominated, because the lucid haze with which the body of a comet is attended sometimes resembles flowing hair. As comparatively little is known of the nature and destination of these erratic bodies, we shall just offer a very few remarks on what has been ascertained respecting their phenomena and motions.

Comets are distinguished from the planets and fixed stars by being usually attended with a long train of light, tending always opposite to the sun, which is called the tail, and which is of a fainter lustre the farther it is from the body of the comet. The luminous point near the centre or head of the comet, whence the tail seems to proceed, is called the nucleus, which appears to be the densest part of the comet. The tail of a comet at its first appearance is very short, and increases as it approaches towards the sun. Immediately after its perihelion, or nearest approach to the sun, the tail is longest and most luminous, and is then generally observed to be somewhat bent, and to be convex towards those parts to which the comet is moving; the convex side being rather brighter and better defined than the concave side. When the tail has attained its greatest length, it quickly decreases, and vanishes entirely from the sight about the same time that the comet itself ceases to be visible. Of what kind of matter the tail consists has been matter of conjecture, and various opinions have been broached on this subject, but nothing is certainly known respecting it. It is evident, however, whatever may be the matter of this substance, that it is exceedingly rare, and so very pellucid that the light of the smallest stars

suffers no sensible diminution in passing through it. Sir J. Herschel says, that he "could distinguish stars of the sixteenth magnitude, through the thickest part of a comet, as it passed over them, covering them with perhaps 50,000 miles of cometic matter.

The tails of comets are found sometimes to occupy an immense space in the heavens. The comet of 1680 stretched its tail across an arch of 104 degrees, and the tail of the comet of 1769 subtended an angle of 70 degrees. The real length of the tail of the comet of 1680, was estimated at 112 millions of miles; that of 1769, at 44 millions, and that of 1744, at eight millions of miles. Sir W. Herschel estimated the length of the tail of the great comet which appeared in 1811, at one hundred millions of miles, a space larger than the whole distance between the earth and the sun; and its breadth was calculated at about fifteen millions of miles. We may just simply mention the opinions of different philosophers, respecting those long trains of light. Tycho Brahe supposed them to be the light of the sun transmitted through the nucleus of the comet, which he believed to be transparent like a lens. Kepler thought that the impulsion of the solar rays drove away the denser parts of the comet's atmosphere, and thus formed the tail. Sir I. Newton supposed that it is a thin vapour, raised by the heat of the sun from the comet. Euler maintained that the tail is occasioned by the impulsion of the solar rays driving off the atmosphere of the comet, and that the curvature observed in the tail is the joint effect of this impulsive force, and the gravitation of the atmospherical particles to the solid nucleus. Mairin imagined that comet's tails are portions of the sun's atmosphere. Dr. Hamilton supposed them to be streams of electric matter. Biot, the French philosopher, supposes that the tails are vapours produced by the excessive heat of the sun, and also that the comets are solid bodies before they reach their perihelion, but that they are afterwards either partly or totally converted into vapour by the intensity of the solar heat. Notwithstanding these opinions of eminent philosophers, we must still admit that the true cause of the extraordinary phenomenon of the tails of comets remains yet unknown. When we consider that these vast streams of light extend, in some instances, to eighty and a hundred millions of miles in length, we cannot conceive that any of the causes assigned above will account for such a wonderful phenomenon. If they consist of vapour raised from the comet, why should this vapour extend to such a prodigious length through space, and why should it be illu-

minated throughout its whole extent? for if it were opaque, or unilluminated vapour, it would be invisible.

In ancient times, comets were generally supposed to be meteors, or exhalations, generated by inflammable vapours in the earth's atmosphere. But it is now ascertained, beyond a doubt, that comets move in regions far beyond the limits of our atmosphere, and form a portion of the solar system. But they differ in many respects from the various planetary bodies, formerly described. In regard to planets, their orbits are all confined to a certain zone, or region of the heavens, of no great breadth, except in the case of Pallas. This zone, in the case of the old planets, contains about eight degrees on each side of the ecliptic. But the orbits of the comets cut the ecliptic in every direction, and, in some instances, their orbits are directly perpendicular to it. They likewise differ from the planets in the form of their orbits. The orbits of most of the planets, though elliptical, approach very nearly to circles; but those of comets are long narrow ellipses, whose length is many times greater than their breadth, and, in most cases, the full extent of their elongation cannot be traced. Only one small portion of these orbits lies within the limits of our observations, and their remotest boundaries are far beyond the range of human vision. Hence it is, that we perceive a comet only for a very short time, and during a very small part of its course, the remaining parts of its course being performed in regions beyond the reach even of our telescopic vision, and beyond the orbit of the remotest planet.

The following are some of the more remarkable comets which have appeared within the last century and a half. The most splendid of these bodies which have appeared in modern times was the comet of **1680**. The tail of this comet is said to have reached from the zenith to the horizon, an extent of ninety degrees. When nearest the sun it was calculated to have been within **150,000** miles of his surface, and its rate of motion at that time was computed at about a million of miles an hour. The period of its revolution round the sun was calculated at **575** years; and if this computation be correct it will not again visit this part of the system till the year **2255**. Another comet which has excited a considerable degree of interest and attention, is that which appeared in **1682**, and is known by the name of Halley's comet. Dr. Halley computed the period of this comet at **75** or **76** years, and predicted that it would again appear about the end of **1758**, or the beginning of **1759**. It accordingly arrived at its perihelion on the **13**th March, **1759**. If **76** years be the

real period of this comet, then it behoved to re-appear in 1835, which happened accordingly. It was seen at Rome on the 5th of August that year, and arrived at its perihelion on the 16th November. The period of this comet, then, is determined, and it is proved, at the same time, that comets are permanent bodies belonging to the solar system. At the remotest point of its orbit, this comet is computed to be 3,400,000,000 of miles from the sun, or nearly double the distance of Uranus.

Another brilliant comet appeared in 1744, the diameter of the nucleus of which was nearly equal to the apparent disk of the planet Jupiter; and its tail, which was divided into six streams of light, was reckoned to be 23,000,000 of miles in length. In 1807, a large comet made its appearance in the month of October, and continued to be visible to the naked eye for nearly two months. The diameter of its nucleus was calculated by Schrœter to be 4600 miles, and the diameter of its coma, or nebulosity surrounding the nucleus, 120,000 miles; its motion was frequently at the rate of 55,000 miles an hour. A still more splendid comet made its appearance in September, 1811, which was visible to the naked eye for more than three months in succession. Schrœter computed the diameter of this comet at 50,000 miles, and Sir W. Herschel estimated the length of its tail at 100,000,000 of miles. When nearest the earth it was distant about 113,000,000 of miles. We shall notice only two other comets, remarkable on account of the shortness of their periods. The first of these comets to which I allude is called the Encke comet, from Professor Encke, who first ascertained its period. It performs its revolution in a period shorter than that of any comet yet known; namely, in 1200 days, or three years and three-tenths. Its orbit penetrates within the orbit of Mercury, but does not extend so far as the orbit of Jupiter. It is a very small body, and is scarcely distinguishable by the naked eye. The other comet is that of Biela, sometimes called Gambart's comet, which finishes its revolution in a period of $6\frac{3}{4}$ years. It was seen in 1826, 1832, and 1839, and in February and March, 1846. It is likewise a very small comet, and cannot be seen without a telescope.

The number of comets has been estimated to be very great. Seven or eight hundred of these bodies have been observed in different ages; but there are only a little more than a hundred of them, the elements of whose orbits have been accurately calculated, so as to identify them should they again make their appearance. By far the greater number are invi-

sible to the naked eye, and even beyond the reach of telescopes, and many of them, doubtless, pass along our hemisphere in the daytime, when they cannot be perceived. From calculations formed on probable grounds, M. Arago concludes that the number of comets which visit the solar system within the orbit of Uranus, is at least 3,000,000. Of late, within the space of fourteen months, five or six comets have made their appearance; one in December, 1843, in the constellation of Orion; another in August, 1844, not far from the star Arcturus, in the constellation Bootes; a third was seen in September of the same year, near the constellation Cetus; a fourth was seen in the month of January, 1845, in the West Indies, and which was visible to the naked eye, but was not seen in this country on account of its great southern declination; a fifth was seen in this country in February, 1845, near the constellation of Ursa Major, and about the same time another was said to have been seen in the East Indies. We had an opportunity of seeing two of these comets, but they were both invisible to the naked eye.

In former ages, the appearance of a comet was viewed as the forerunner of disastrous events, such as wars, famine, pestilence, the revolutions of nations and empires, the death of kings and princes, inundations, earthquakes, and similar calamities. But we need scarcely say that there is not the least foundation for such apprehensions; for comets are every year making their appearance to the astronomical observer, while both the physical and the moral world is moving on in its regular course. The comets are, doubtless, messengers of the Deity sent forth to accomplish the designs he intended in their creation; but we have not the least reason to believe that they were ever intended to "shake from their horrid hair" wars, famine, and pestilence upon the nations. Their destination, whatever it may be, must be in full accordance with the benevolence of him whose "tender mercies are over all his works." It has, indeed, been apprehended by some that a comet in crossing the path of the earth, might happen to come into collision with it, and produce a shock which would shatter its present constitution, and prove destructive to its inhabitants. It is admitted that this is a possible circumstance, though the chances in favour of it, according to Arago, are only as one to 281,000,000. In France and other parts of the European continent, in 1773, an apprehension of this kind was excited, which was attended with many serious consequences. People of weak minds, it is said, died of fright, and women miscarried. A similar alarm was pro-

duced in 1832, when it was announced that the comet of Biela, on the 29th of October, would cross the plane of the ecliptic at a point near where the earth would be on the 30th of November following; but before the earth arrived at that point, the comet was distant from it 50,000,000 of miles. All such forebodings and alarms may be considered as entirely without foundation. At least, the believer in Divine revelation has nothing to fear, for he knows that the purposes of the Almighty in respect to this world are not yet nearly completed, and that many of the most prominent predictions of inspired prophets are not yet accomplished. Wars must cease to the ends of the earth. The knowledge of Jehovah must cover the earth. The Jews must be converted to the faith of Messiah. The kingdoms of this world must "become the kingdoms of our Lord, and of his Christ," and righteousness and praise must spring forth before all nations, before a comet or any other celestial agent shall be permitted to impinge upon our globe, or to alter its present constitution; and centuries must necessarily elapse before such objects are fully accomplished.

As to the destination of comets, or the purposes they are intended to serve, in the economy of the universe, we are in a great measure ignorant, as we are unacquainted with the nature and constitution of these singular and anomalous bodies. But as they are all the workmanship of Him who is "wonderful in counsel, and excellent in working," they must be intended to subserve important purposes in the system of creation, worthy of the perfections of Him who is infinite in knowledge, who "established the world by his wisdom, and hath stretched out the heaven by his understanding." So many thousands, or even millions of these blazing orbs, as are continually traversing the regions of the planetary system, were not created in vain. The adjustment of their motions, and the arrangement of their orbits, so as not to interfere with each other, nor with the motions of the planets, is an evidence of that Divine wisdom which is displayed throughout every part of creation. The number of these bodies, the vast magnitude of their blazing tails, and the amazing velocity with which they move in certain parts of their orbits, display the Almighty power of Him who at first set them in motion: and although we are partly ignorant of the ultimate designs they are intended to accomplish, yet we may rest assured that they form a part of that plan of Divine beneficence, which appears a prominent object in all the works of God. There seems no improbability in the supposition, that they are in-

tended as habitations for various orders of intellectual beings, to whom the Almighty displays himself in a peculiar manner, different from that of the inhabitants of the planets, and whose corporeal organization is exactly adapted to the nature and properties of the world in which they are placed. For we have every reason to believe that an infinite variety exists in the universe, in respect both to the physical and mental constitution of the intelligences it contains.

CHAPTER VI.

N THE ECLIPSES OF THE SUN AND MOON.

The term eclipse is derived from a Greek word, which signifies to be diminished, to faint away, to swoon, or to die. When the full moon, in her greatest lustre, is deprived of the beams of the sun, she appears pale and languid, as if she were sick and dying. Hence the superstitious among the ancients imagined that the moon was in pain at such times, and therefore lunar eclipses were called the labours of the moon; and, in order to relieve her in that fancied distress, they were accustomed to hold up on high lighted torches; to blow with horns and trumpets; to make a loud noise, by beating on vessels of brass and iron, to break, if possible, the enchantment that had fallen on the lunar orb. Before the true causes of eclipses were ascertained, those phenomena were considered as supernatural, and viewed with apprehension and alarm. It was believed that they were produced by the immediate interposition of God, as a token of his displeasure. When the sun was totally eclipsed, it was imagined, by many of the ancients, that he turned away his face, in abhorrence of some atrocious crime that had been committed, or was about to be perpetrated on the earth, and threatened mankind with everlasting night. When the Medes and Persians, several centuries before Christ, were preparing to engage in furious combat, they were so alarmed at an eclipse, which happened at that time, that the warriors on both sides laid down their arms, and entered into a treaty of peace. When the fleet of Pericles, the celebrated Grecian, was preparing to attack Peloponnesus, there happened an eclipse of the sun, which was considered as a most unfortunate omen; and the whole of the Athenian commanders and their men were thrown into the greatest consternation. Such

facts should inspire us with gratitude for the advantages we now enjoy, in a land where science is cultivated, and useful knowledge disseminated, and where the light of Divine revelation has dispelled the darkness and superstitions of the heathen world.

Every planet and satellite is enlightened by the sun, and, consequently, casts a shadow towards the point of the heavens which is opposite to that luminary. An eclipse, therefore, is a privation of the light of the sun, or of some other heavenly body, by the interposition of another body between it and our sight. Eclipses are either of the sun, or the moon, or of the satellites which accompany some of the planets. In regard to circumstances, they are divided into total, partial, annular, and central. A total eclipse is when the whole face of the luminary is darkened; a partial eclipse is one when only a part of the disk is darkened; an annular eclipse is when the whole is darkened except a ring, or annulus, which appears round the dark part like an illuminated border. This can only happen in the case of an eclipse of the sun. In a central eclipse, the centres of the two luminaries and that of the earth are in one and the same right line, as when in an eclipse the moon passes through the centre of the earth's shadow.

SEC. I.—ON THE ECLIPSES OF THE MOON.

An eclipse of the moon is produced by the interposition of the earth between the sun and moon, and, consequently, it can only happen at the time of full moon, when the moon is in opposition to the sun. As the earth is an opaque body, enlightened by the sun, it will cast a shadow towards those portions of space which are opposite to the sun, and if the moon happen to pass through those spaces where the shadow falls, she must necessarily be eclipsed. The sun and the earth are both spherical bodies, and, therefore, if they were of an equal size, the shadow of the earth would be cylindrical, as in fig. 54, and would continue of the same breadth, at all distances from the earth, and would extend to an equal distance, and might cause an eclipse of the sun to the superior planets. If the sun were less than the earth, the shadow would expand, and grow wider the farther it was from the earth, as in fig. 55. It would reach the orbits of Mars, Jupiter, Saturn, and Uranus, and eclipse them, when the earth interposed between them and the sun; and these eclipses, in the case of the most distant planets, would be of long duration, on account of the shadow being broader in proportion to

the distance. But as such eclipses never happen, it forms a demonstrative proof that the sun is not less, but greater than

Figure 54.

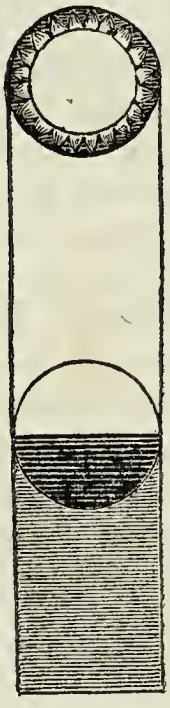


Figure 55.

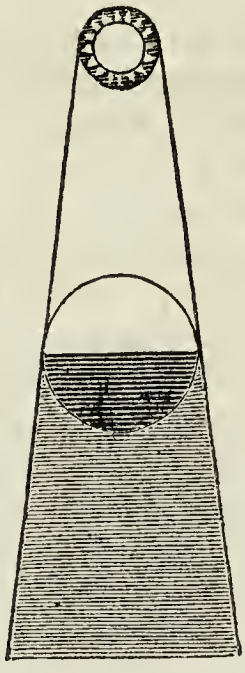


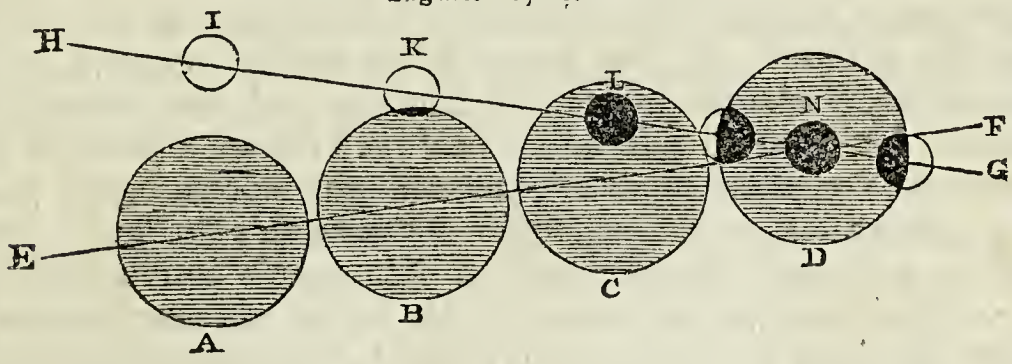
Figure 56.

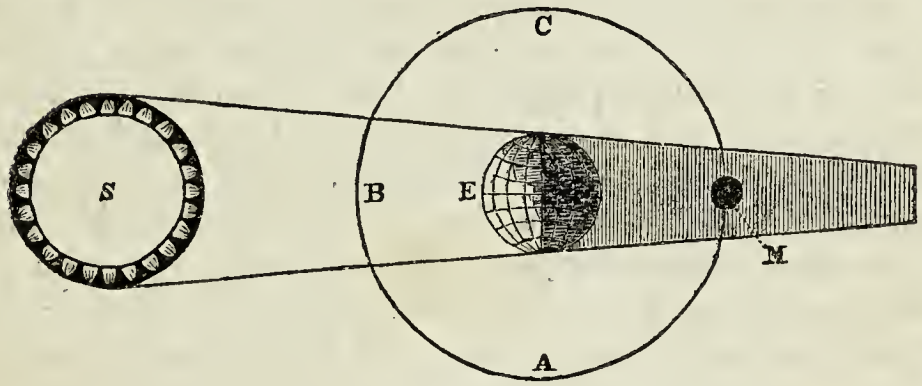
the earth. The sun, then, being greater than the earth, the shadow of the earth is a cone, which ends in a point at a certain distance from the earth, as represented in fig. 56. This cone reaches to a distance of 840,000 miles from the earth, or about three and a half times as long as the distance of the moon from the earth.

If the moon always moved in the plane of the ecliptic, she would suffer a total eclipse, at the time of every full moon, by passing through the centre of the earth's shadow. But the moon's orbit is inclined to the plane of the ecliptic, at an angle of 5° 8′, and coincides with it only in two places, called the nodes, or the points where her orbit intersects the ecliptic. Full moon, therefore, may frequently happen without an eclipse, as at this period the moon may be either to the north or the south of the ecliptic. It has been calculated, that if the mean opposition of the sun and moon, or the full moon, happen within 7° 47′ of the moon's node, there must be an eclipse; but if the distance be greater than 13° 21′, there cannot be an eclipse. Let H G, fig. 57, represent the moon's orbit, E F the plane of the ecliptic, and N the node of the orbit, or point where it cuts the ecliptic; and A B C D four representations of the earth's shadow in the ecliptic. It is obvious that when the shadow is at A, and the moon at I, there will be no eclipse, because the moon is too far from the node, and

the earth's shadow does not reach her. When the full moon is nearer to the node, as at K, only a part of her disk passes through the shadow, when she suffers a partial eclipse. When the full moon is at L, she passes through a portion of the shadow, and is totally eclipsed. When the moon's centre passes through the centre of the shadow, which can only happen when she is in the node at N, it is then both a total and a central eclipse; and such an eclipse is of the longest

Figures 57, 58.





duration—at which time the total darkness continues about two hours.

Fig. 58 represents, in a different point of view, a total eclipse of the moon. The circle A B C represents the orbit of the moon, in which it revolves round the earth. The moon is supposed to be in the node, and in her opposition to the sun—she therefore passes through the centre of the earth's shadow. And as the shadow of the earth is nearly 6000 miles broad at the distance of the moon, and as the moon is only a little more than 2000 miles in diameter, she must be completely immersed in the shadow of the earth, and must move nearly three times her own diameter before she can emerge from the shadow.

The following facts may be stated in relation to lunar eclipses:—1. An eclipse of the moon always begins on the

moon's eastern side, and goes off on her western side. 2. Lunar eclipses are visible in all parts of the earth which have the moon above their horizon, and are everywhere of the same magnitude and duration. 3. The moon's diameter is supposed to be divided into twelve equal parts called digits, and as many of these parts as are darkened by the earth's shadow, so many digits is the moon said to be eclipsed. The extent in which the moon is eclipsed above twelve digits shows how far the shadow of the earth is over the body of the moon on that edge to which she is nearest at the middle of the eclipse. 4. The moon, when totally eclipsed, is not invisible, if she be above the horizon and the atmosphere clear; but appears generally of a dusky colour, somewhat like tarnished copper, especially towards the edges, being generally more dark about the middle of the earth's shadow. Some have supposed this to arise from the moon's native light, but the true cause of her being visible is, the scattered beams of the sun bent into the earth's shadow, by passing through its atmosphere. The moon is not eclipsed by the earth alone; the atmosphere, by refracting some of the rays of the sun, and reflecting others, casts a shadow, though not so dark a one as that which arises from an opaque body. Although in most lunar eclipses the body of the moon, though obscured, is still visible, yet it has sometimes happened otherwise. Hevelius mentions, in his "Selenographia," an eclipse of the moon which happened in August, 1647, when he was not able to distinguish the face of the moon even with a good telescope, although the sky was sufficiently clear for him to see stars of the fifth magnitude: but such cases are rare.

The duration of a lunar eclipse depends on the following circumstances:—1. On the largeness of the circle of the earth's shadow, whose diameter may be different at different times; the nearer the moon is to the earth, the larger is that portion of the earth's shadow through which she passes. 2. On the apparent diameter of the moon, which may be different, on account of her variable distance, as she moves in an elliptical orbit. 3. On the distance of the moon from her node at the moment of her being full, which will cause her to pass through a greater, or less, portion of the earth's shadow. Thus when the moon is at K, fig. 57, the eclipse will be of comparatively small duration; when at L, its duration will be much longer, but not so long as when she is at N, in the node, when she passes through the centre of the shadow. 4. On the velocity of the moon's motion across the shadow of the earth, which is swiftest when she is in perigee, or nearest the

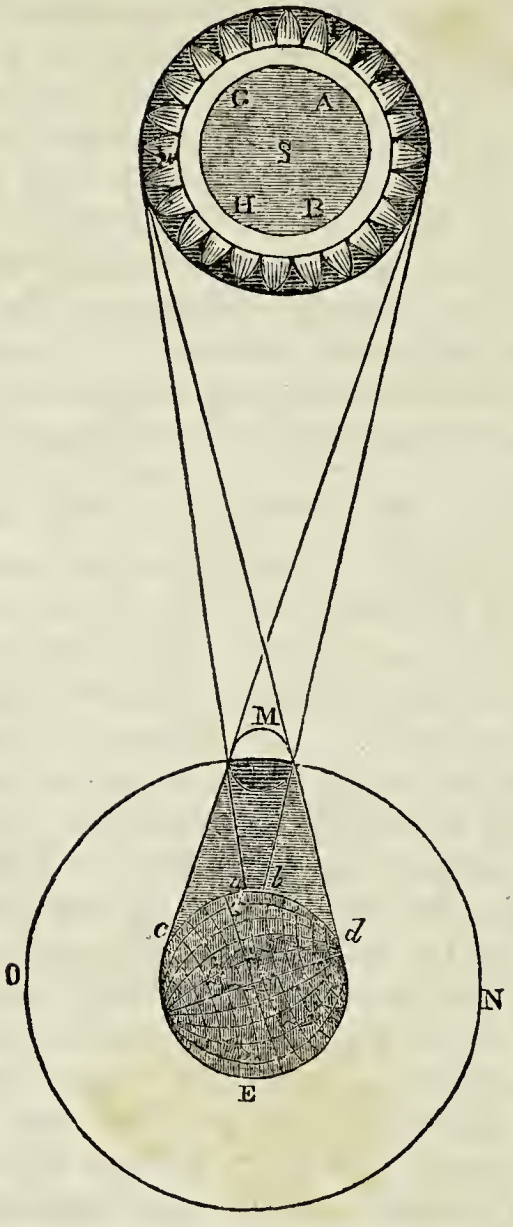
earth, and the duration of a central eclipse will then be shortest. According to these circumstances will be the time of continuance of a lunar eclipse. When the moon is centrally eclipsed, and when she is at her greatest distance from the earth, its duration is 3 hours, 57 minutes, 26 seconds, from beginning to end: and when she is at her least distance, 3 hours, 37 minutes, 26 seconds. The moon may be totally eclipsed, although she do not pass through the centre of the shadow; but in this case the duration of the eclipse will be shorter than what has been now stated. In some instances, the continuation of total darkness may amount only to a few minutes, when the moon passes near the extremity of the shadow.

SEC. II.—ON ECLIPSES OF THE SUN.

An eclipse of the sun is caused by the interposition of the body of the moon between the sun and the earth, when she throws a shadow over a certain portion of the earth. This can happen only at the time of new moon, and when the moon is at or near one of her nodes. The eclipses of the sun and moon, though expressed by the same word, are in their nature very different; the sun, in reality, loses nothing of his native lustre in the greatest eclipse, but is all the while diffusing streams of light around him in every direction, and illuminating without intermission all the bodies in the planetary system. Some of these streams, however, are occasionally intercepted in their course towards the earth by the moon coming between the earth and sun, and at that time the dark side of the moon is turned towards the earth. When the moon is eclipsed, she suffers a real diminution of her borrowed light; but when the sun is said to be eclipsed, there is no diminution of his light, and it is in reality an eclipse of the earth by the shadow of the moon falling upon a certain portion of our globe: and this shadow would be distinctly seen, by an inhabitant of the moon, passing along a certain zone of the earth, like a small, dark, circular spot. The moon being much smaller than the earth, and having a conical shadow—because she is less than the sun—can cover only a small part of the earth by her shadow: hence an eclipse of the sun is visible only to a few inhabitants of the earth, whereas an eclipse of the moon is visible to all who are on that hemisphere, where the lunar orb is seen.

The following diagram, fig. 59, will convey a general idea of the nature of an eclipse of the sun. In this figure, s represents the sun; M, the moon; E, the earth; and M N O, the orbit of the moon. The moon is supposed to be in that part

Figure 59.



of its orbit next the sun, having the enlightened side towards the sun, and its dark hemisphere wholly turned towards the earth, which is its position at new moon. It is also supposed to be in its node, in an exact line between the sun and the earth. In this situation the shadow of the moon falls upon a certain portion of the earth, and intercepts the rays of the sun, for a little, from the inhabitants of the earth on whom the shadow falls. Part of the cone of the shadow is represented at *a b*, and it is never more than about 180 miles in diameter, within the limits of which the sun will appear totally eclipsed. But sometimes it happens that the extremity of the cone of the moon's shadow falls short of the earth, in which case an annular eclipse of the sun is produced; in which the sun appears like a brilliant ring of light around the dark body of the moon. Besides the dark shadow, there is a penumbra or

fainter shadow produced, which is represented at *c d;* and in all those parts where the penumbra falls, the sun will be only partially eclipsed. Thus, between *c* and *a*, the parts of the sun about A B cannot be seen; the rays coming from thence towards *c* or *a* being intercepted by the moon; but the portions of the sun about G and H will be visible. The nearer any place of the earth—within the penumbra—is to the dark shadow of the moon, the greater will the eclipse appear, and the nearer it is to the outside of the penumbra, the smaller will be that portion of the sun which is seen eclipsed. To those who live beyond the boundary of the penumbra, the whole disk of the sun will be seen and no eclipse will be visible. Hence it happens, that the sun may be totally eclipsed in Africa and the southern parts of Asia, and no trace of an eclipse perceived, at the same moment, either in Britain or America.

The following are some facts in relation to solar eclipses:—1. If the mean conjunction of the sun and moon takes place within 15 degrees of the moon's node, there must be an eclipse of the sun; but if the conjunction happen at a greater distance from the node than 21 degrees, there can be no eclipse. Therefore, between 15 degrees and 21 degrees there may, or may not be an eclipse. 2. The penumbra covers a space of 4900 miles in diameter, within which the sun will appear more or less eclipsed. 3. The motion of the moon's shadow over the earth's surface is equal to her motion in her orbit, which is about 2200 miles in an hour; a velocity four times as great as that of a cannon ball. 4. The number of eclipses in any year cannot be less than two, and those both of the sun; nor can they be ever more than seven: in which case there will be five of the sun, and two of the moon, and the moon's eclipses will be total. The usual number is four in a year, two at each node, and nearly half a year intervenes between the two sets of eclipses. 5. The sun is never totally eclipsed longer than about four minutes, but the moon may be immersed in the earth's shadow, or totally eclipsed, about 1 hour and 48 minutes. 6. Eclipses of the sun are more frequent than eclipses of the moon, because the ecliptic limits of the sun are greater; but we have more visible eclipses of the moon, because they are seen to the whole hemisphere next her; while eclipses of the sun only are visible from a very small portion of the earth's surface. 7. An eclipse of the sun begins on the western side, and ends on the eastern.

Periods of Eclipses.—It has been found that in 223 mean

lunations, after the sun, moon, and nodes have been once in a line of conjunction, they return so nearly to the same state again, that the same node which was in conjunction with the sun and moon, at the beginning of the first of these lunations, will be within less than half a degree of a line of conjunction with the sun and moon again, when the last of these lunations is completed. Therefore, in that time, there will be a regular period of eclipses for many ages. In this period there are 18 Julian years, 11 days, 7 hours, 42 minutes, 31 seconds; when the last day of February in leap years is four times included. Consequently, if to the mean time of any eclipse, either of the sun or moon, we add the above period, we shall have the mean time of the return of the same eclipse. During this period, there happens about 62 eclipses, 21 of the moon and 41 of the sun. If, then, we wish to know the mean time of an eclipse for any year, we have only to seek in old almanacs the exact time that any eclipse may have happened 18 years before, and add to such time the above-mentioned period.

From what has been now stated respecting solar eclipses, it is evident that the darkness which accompanied our Saviour's crucifixion must have been supernatural. For it happened at the time of the Jewish passover; and that festival, by the appointment of the law, was to be celebrated at full moon, at which time it was impossible that the shadow of the moon could fall upon the earth, or the sun be eclipsed, according to the established laws of nature. Besides, in a total eclipse of the sun, the time of the continuance of total darkness is not more than about four minutes; but the darkness which overspread "the whole land" while our Redeemer hung upon the cross, continued without intermission for more than three hours. And again, although the sun had been totally eclipsed in a natural way, at that time, to the inhabitants of Jerusalem and its confines, it would have been only partially eclipsed to those who dwelt on the out-skirts of the land of Judæa; as the shadow of the moon, in an eclipse of the sun, covers only a small part of the earth's surface at one time. In confirmation of what has been now stated, it has been calculated by some astronomers, that an eclipse of the moon, which can only take place at the time of full moon, happened on the afternoon of that day on which our Saviour was crucified; so that according to the language of the prophet, "The sun and the moon were both darkened in their habitation," at the time when this solemn and interesting event was accomplished.

Total eclipses of the sun have always been considered as remarkable events. Clavius remarks, that at the total eclipse of the sun which happened in 1560, the darkness at Coimbra, in Portugal, was greater, or at least more striking than that of the night, and that the birds fell to the earth through terror. At Berne, in Switzerland, on May 1, 1706, the sun was totally darkened for four minutes, during which time a fixed star and a planet appeared very bright. The sun's passing out of the eclipse was preceded by a blood-red streak of light from his left limb, which continued about 6 or 7 seconds; then part of the sun's disk appeared all on a sudden brighter than Venus was ever seen in the night,—and in that instant gave light and shadow to objects as strong as the moonlight generally does. One of the most minute accounts of the circumstances accompanying a total eclipse of the sun is that which is given by Dr. Stukeley, of the eclipse which happened in 1724, in a letter to Dr. Halley; of which the following is an abridgment:—

"I chose for my station, Haradon-hill, near Amesbury, east from Stonehenge avenue. In front is that celebrated edifice upon which I knew that the eclipse would be directed. I had the advantage of a very extensive prospect in every direction, being on the loftiest hill in the neighbourhood, and that nearest to the centre of the shadow. I had two men in company who looked through smoked glasses. The sky, though overcast, gave out some straggling rays of the sun that enabled us to see around us. It was half-past five by my watch when they informed me that the eclipse was begun. We watched its progress by the naked eye, as the clouds performed for us the service of coloured glasses. At the moment when the sun was half obscured, a very evident circular rainbow formed at its circumference with perfect colours. As the darkness increased we saw the shepherds on all sides hastening to fold their flocks, for they expected a total eclipse of an hour and a quarter duration. When the sun assumed the appearance of the new moon, the sky was tolerably clear, but it was soon covered with deeper clouds. The rainbow then vanished; the hill grew very dark, and on each side the horizon exhibited a blue tint like that at the close of day. Scarcely had we time to count ten, when Salisbury spire, six miles to the south, was enveloped in darkness. The hill disappeared entirely, and the deepest night spread around us. We lost sight of the sun, whose place till then we had been able to distinguish in the clouds, but whose trace we could now no more discover than if it had never existed. It was

now 35 minutes past six; shortly before the sky and the earth had resumed a livid tint; there was also much black diffused through the clouds, so that the whole picture presented an awful aspect that seemed to announce the death of nature.

"We were now involved in a total and palpable darkness. It came on rapidly, but I watched so attentively that I could perceive its progress. It came upon us like a great dark mantle thrown over us. The horses we held by the bridle seemed deeply struck by it, and pressed closely to us with marks of extreme surprise. As well as I could perceive, the countenances of my friends wore a horrible aspect. It was not without an involuntary exclamation of wonder, I looked round me at this moment: I distinguished colours in the sun, but the earth had lost all its blue, and was entirely black. A few rays shot through the clouds for a moment, but immediately afterwards the earth and the sky appeared totally black. It was the most awful sight I had ever beheld in my life. North-west of the point whence the eclipse came on, it was impossible to distinguish in the least degree the earth from the sky, for a breadth of 60 degrees or more. We looked in vain for the town of Amesbury, situate below us; scarcely could we see the ground under our feet. All the change I could perceive during the totality was that the horizon by degrees drew into two parts, light and dark; the northern hemisphere growing still longer, lighter, and broader, and two opposite dark parts uniting into one, and swallowing up the southern enlightened part.

"At length, upon the first lucid point appearing in the heavens where the sun was, I could distinguish pretty plainly a rim of light running alongside of us, a good while together, or sweeping by our elbows, from west to east; just then, having good reason to suppose the totality ended, I found it to be full three minutes and a half. The hill-tops then resumed their natural colour, and I saw no horizon at the point previously occupied by the shadow. My companions cried out that they again saw the steep hill towards which they had been looking attentively. Presently we heard the song of the larks hailing the return of light, after the profound and universal silence in which every thing had been plunged. The heavens and the earth now appeared of a grayish cast, interspersed with blue, like the morning before sunrise. As soon as the sun appeared, the clouds grew denser, and for some minutes the light did not increase, as happens at a cloudy sunrise. The instant the eclipse became total, till the emer-

sion of the sun, we saw Venus, but no other stars. We perceived at this moment the spire of Salisbury Cathedral. The presence of the clouds added much to the solemnity of the spectacle, incomparably superior, in my opinion, to the eclipse of 1715, which I saw perfectly from the top of Boston steeple, when the sky was very clear. There, indeed, I saw the two sides of the shadow, coming from afar, and passing to a great distance behind us; but this eclipse exhibited great variety, and was more awfully imposing. So deep an impression has this spectacle made on my mind, that I shall long be able to recount all the circumstances of it with as much precision as now."

There have been no total eclipses of the sun in Britain, since those of 1715 and 1724, nor will there be one visible here during the present century. The first total eclipse in England will happen on the 3d of February, 1916. The most remarkable solar eclipses for the next half century are those of March 15, 1858, and August 19, 1887. The last total eclipse of the sun visible in Europe, happened on July 8th, 1842; of which the following account is abridged from the Athenæum:

"Vienna, July 8, 1842.—The eclipse, the object of our journey to Vienna, was worth going any distance to see. No partial eclipse, however considerable, can give the faintest notion of what a total one is. All Vienna was in expectation for many days previous to the event, and strangers flocked to that capital in crowds to witness that phenomenon. The celebrated astronomer, Schumacher, came all the way from Denmark on purpose to see the eclipse, with astronomical eyes. At four in the morning, I beheld the clear rays of the sun, shining opposite my window, while the general appearance of the sky indicated a favourable concurrence of circumstances. Soon after five, I was on my way to the Botanical Garden, and already the ramparts of the city were thronged with multitudes. About ten minutes before six the first spot of darkness was observed upon the sun. From that time till the total obscuration, there was no very unusual appearance. The sky, about half an hour before the commencement of the eclipse, became somewhat obscured by vapour, and blue mists arose increasingly from the horizon. A perceptible chillness crept into the air, and flights of swallows flew wildly and restlessly through the darkening atmosphere; but as long as the smallest portion of the sun was visible, there was considerable light. But now approached the important moment.

A heavy bell tolled at intervals from the city, like the funeral knell of our beautiful orb of light and life, and the sharp shrill cries of the birds, which had disappeared, as if to take refuge from some impending convulsion of nature. Yet a moment, and on a sudden, an effect took place, unexpected and sublime. The whole aspect of heaven and earth underwent a change, with regard to light, colouring, every thing; and the instant that preceded the total eclipse, resembled in nothing, and gave no idea of that which followed it.

"Round the black sun was an irregular halo of whitish light, defining clearly and strongly the obscured orb. In some places, this halo extended into longer gleams, forming altogether a faint glory. It was not so generally dark as I had supposed it would have been,—but the sudden diminution of light, at the moment of total obscuration, was sudden and startling. Also the sudden diminution of temperature, the thermometer falling 11 degrees instantaneously upon the complete immersion of the sun. One of the most striking and unexpected effects, was a red and lurid glow, that suddenly kindled upon the horizon; the blue pale vapour that had risen from the east, being converted into the semblance of a mighty conflagration. The principal light in the landscape came from thence, no longer from the sun. The rest of the atmosphere was of a sickly greenish tinge, overcast with duskiness, through whose spectral tints the crowds upon the ramparts were dimly discerned, all standing in solemn stillness, like the vast shadowy multitudes in one of Martin's pictures.

"The number of stars visible during this eclipse, at Perpignan, according to Arago, was only ten. The number was greater at Montpelier and Milan. Its effect upon animals was remarkable. One of the friends of Arago had five healthy linnets in a cage, three of which died during the sudden darkness of the eclipse. Oxen formed into a circle, with their horns thrust forward, as if to repel an enemy. At Montpelier bats and owls appeared, sheep lay as if for the night, and horses in the fields were in terror. M. Fraise, a naturalist, relates that a swarm of ants, in full march, stopped short at the moment of occultation, when the darkness was nearly at its height."

The following table contains a statement of the principal solar eclipses during the present century:—

	Beginning of eclipse.				Middle of the eclipse.				End of the eclipse.				Digits eclipsed.	
	h.	min.	sec.		h.	min.	sec.		h.	min.	sec.		deg.	min.
May 6, 1845	8	30	25	morn.	9	51	55	morn.	11	19	55	morn.	5	12
April 25, 1846	5	42	0	even.	6	30	0	even.					3	42
Oct. 9, 1847	6	22	38	morn.	7	36	38	morn.	8	48	38	morn.	11	0
July 28, 1851	1	57	11	even.	3	5	11	even.	4	10	41	even.	9	43
March 15, 1858	11	29	30	morn.	12	52	2	even.	2	12	0	even.	11	30
July 18, 1860	1	34	30	even.	2	45	0	even.	3	52	30	even.	9	12
Dec. 31, 1861*	2	5	0	even.	3	4	0	even.					6	13
May 17, 1863*	6	0	0	even.	6	46	0	even.	7	30	0	even.	3	58
Oct. 19, 1865	3	55	58	even.	5	9	58	even.	6	17	28	even.	7	36
Oct. 8, 1866*	5	2	0	even.	Sun sets 5h. 32m.								3	58
March 6, 1867	8	7	26	morn.	9	21	26	morn.	10	40	26	morn.	8	42
Feb. 23, 1868*	3	42	0	even.	3	54	0	even.	4	6	0	even.	0	9
Dec. 22, 1870	11	15	28	morn.	12	32	58	even.	1	48	28	even.	9	36
May 26, 1873*	7	56	0	morn.	8	48	0	morn.	9	34	0	morn.	3	36
Oct. 10, 1874*	8	55	7	morn.	10	13	37	morn.	11	34	37	morn.	6	18
Sept. 29, 1875*	11	56	0	morn.	12	37	0	even.	1	7	0	even.	2	7
July 19, 1879*	7	45	0	morn.	8	39	0	morn.	9	41	0	even.	4	8
Dec. 31, 1880*	1	49	0	even.	2	47	0	even.	3	36	0	even.	4	28
May 17, 1882*	6	22	0	morn.	7	0	0	morn.	7	49	0	morn.	3	19
Aug. 19, 1887	3	25	22	morn.	4	15	22	morn.	5	7	52	morn.	11	58
June 17, 1890*	8	19	0	morn.	9	22	0	morn.	10	48	0	morn.	5	46
May 28, 1900*	3	21	0	even.	4	30	0	even.	5	23	0	even.	7	53
Aug. 30, 1905	11	54	52	morn.	1	8	42	even.	2	19	42	even.	9	30
April 17, 1912	10	48	12	morn.	12	23	12	even.	1	45	12	even.	11	30
Feb. 3, 1916	4	21	10	even.	5	21	40	even.	6	18	10	even.	12	0

In the above table, the eclipses marked with an asterisk are calculated for the meridian of Paris; all the others are calculated for the middle of England.

Eclipses are not only striking and interesting phenomena of nature, but are of considerable advantage and utility. In the first place, from an eclipse of the moon we derive one

conclusive argument to prove the globular figure of the earth, from the circular shape of the shadow of the earth in a lunar eclipse. 2. Eclipses of the moon prove that the sun is larger than the earth, because the shadow of the earth shortens in its breadth as it retires from the earth, and at length terminates in a point, which it could not do if the sun were smaller. 3. They also prove that the earth is larger than the moon, because the whole of the moon's body is sometimes involved in the earth's shadow, and a section of this shadow at the moon is much less than the earth itself. 4. The longitude of places may be obtained by eclipses to a great degree of accuracy. An eclipse commencing at the same moment of time to all places at which it is visible, the difference in the observed time at any two places will give the difference of longitude between the places. 5. Eclipses have lent their aid in settling the precise date of ancient historical events. For if near the time of any memorable event recorded in history, a remarkable solar or lunar eclipse be also recorded, we may know whether the real time of this event be rightly determined, by calculating backwards, and ascertaining whether any remarkable eclipse happened near the period supposed. For example, Thucydides relates that a solar eclipse happened on a summer's day, in the afternoon, in the first year of the Peloponnesian war, which eclipse was so great that the stars appeared. This is stated in modern authors to have been in the year 413 before Christ, and by computation it appears that on the 3d of August in that year, there was a great solar eclipse, which passed over Athens about six o'clock in the afternoon; which therefore corroborates the decision of chronologers.

CHAPTER VII.

ON THE SEASONS, AND THE DIFFERENT LENGTHS OF DAYS AND NIGHTS.

We formerly had occasion to state that the earth revolves round ts axis every 24 hours, and round the sun in about 365 days and nearly 6 hours. These motions are intimately connected with the different lengths of days and nights, experienced in almost every region of the globe, and with the seasons which diversify the different portions of the year.

The constant succession of day and night—though so common as to be almost unheeded—is in reality a very wonderful operation of the Most High. When, after a dark and tempestuous night, the sun first appears in the unclouded horizon, all nature appears animated by his presence. The magnificent scene of creation, which a little before was involved in obscurity, opens gradually to view—and every object around has a tendency to excite sentiments of delight and adoration, if man were disposed to contemplate the works of his Creator with intelligence and pious emotion. The heavens are adorned with azure, the clouds are tinged with the most lovely hues, the flowers expand their buds, and put forth their colours; the birds awake to melody, and the insect tribes are on their wing, all rejoicing in the light of the luminary of day. The curtain of darkness is likewise removed from the abodes of men, which were previously obscured, and we behold the cities, towns and villages, the lofty domes, the glittering spires, and the palaces and temples with which the landscape is adorned. After a night of darkness and tempest, such a scene appears almost like a new creation. The sun, after moving in all his brightness through the canopy of heaven, is again hidden from our view in the western region of the sky, and we are then presented with a scene still more wonderful and sublime: the moon rises in unclouded majesty—the planets are beheld moving in their different courses, and an innumerable host of stars, spread over the whole concave of the firmament, diffuse their radiance from afar. Such a spectacle, during the silence of the night, fills the contemplative mind with solemn thoughts, and with sentiments of wonder and delight, and has a tendency to raise the soul to a consideration of the Great First Cause, "by whom the heavens were made."

In the course of the annual revolution of the earth round the sun, the inhabitants of every country, and of every clime, experience, though at different times, all the variety of the seasons, and the different lengths of days and nights with which they are accompanied. Spring, summer, autumn, and winter, follow each other in constant succession, diversifying the scenery of nature, and distinguishing the different periods of the year. In the present constitution of the earth, and in the present state of man, this vicissitude of seasons is attended with manifold advantages both to the human race and to the other tribes of animated nature, and is necessary towards bringing to maturity the various productions of the earth. During one-half of the year, from March 21, to September 23,

the regions of our globe within the north polar circle enjoy their summer, and part of their spring and autumn. At the north pole, the sun shines six months without intermission; and from 66½ degrees of north latitude, the inhabitants of these climes enjoy a length of day varying from 24 hours to six months;—the nearer the pole, the longer is the day. In Greenland and Davis' Straits, our whale fishers enjoy, during the greater part of the time they are employed in those regions, an almost uninterrupted day of three or four months in length. During the same time, the inhabitants of the antarctic circle around the southern pole, are altogether deprived of the sun, and shrouded in darkness, till the 23d of September; when he again appears on the verge of their horizon. These countries, within the polar circles, may be considered as having only two seasons—summer and winter. They have a summer of about four months, during which the days are very long and the heat considerable. The rest of the year may be considered as winter: for so rapid is the transition from heat to extreme cold, and from cold to heat, that spring and autumn are scarcely perceptible. It is only in temperate climates that four distinct seasons are particularly distinguished and enjoyed. In such climates, in spring, plants have time to shoot, and grow insensibly, without being destroyed by late frosts, or too much hastened by early heats. In summer, the heat gradually diminishes; so that the fruits of autumn have time to ripen by degrees, without being hurt by the winter colds. Throughout most of the European countries, particularly in Italy, and the south of France, these four seasons are distinctly perceptible. In the warmest countries too, as well as in the coldest, there may be said to be only two seasons, that materially differ from each other; as in the tropical climates, about the central parts of Africa, and the southern regions of Asia. In such countries, there is a dry and scorching season, during seven or eight months, till the rainy season commences, which continues generally four or five months; and this is the chief distinction between their summer and winter.

Every season of the year is characterized by its peculiar phenomena and effects. Spring is characterized as the season of the renovation of nature after the gloom and torpor of winter. At this period, animals and vegetables feel the influence of returning warmth, and prepare for the continuance and increase of their several species. The plants and flowers, which were hid in winter, as soon as genial showers refresh the soil, emerge from the ground, and begin to display their

beauties. As the sun rises higher and higher above the horizon at noon, and the heat increases, the larger vegetables, shrubs and trees, unfold their leaves, and the winged tribes begin to build their nests, and to "sing among the branches." The landscape begins to be adorned with a lively green, interspersed with flowers of various hues, and all nature appears in ceaseless activity. In this season, about the 21st of March, the sun crosses the equinoctial; when the days and nights are equal over all the globe, and the north polar regions, which were previously involved in darkness, now begin to feel the light and genial influence of the sun. The approach of spring and its progressive advances, fill the hearts of all, the mendicant as well as the monarch, with hope, and unmixed joy and satisfaction; for this season affords us a thousand new delights. It charms us with the beauty and perfume of flowers; the songs of the winged tribes; the length of the day rapidly advancing; and the preludes of approaching summer, and the pleasures of rural excursions.

Summer has generally been considered, on the whole, as the most delightful season of the year. Every object is then clothed in renovated beauty and gladness—the winter snows are completely melted from the hills; the trees are bursting with leaves; the flowers are painting themselves with every variety of colour, and every thicket, and every hill ring with the modulations of various notes—every thing in the animal and vegetable world now appears in a progressive state towards maturity, and the insect race seem animated with peculiar vigour and activity under the more direct influence of the sun. At this time, (about the 21st of June,) the sun rises highest in his meridian course, the heat increases, the day is at the longest, the night consists only of a few hours of twilight, and the rising sun is accompanied with peculiar sublimity and splendour. The fleecy clouds are painted with purple and vermilion, the mountain-tops are fringed with radiance, and every object on the face of nature displays its peculiar form and beauties. This season, too, is sometimes distinguished by excessive heats, which produce languor and inactivity, and sometimes the sky is covered with dark and lowering clouds, when, on a sudden, the forked lightnings flash, and the thunders roll in awful majesty along the sky, appalling the timorous mind and producing terror among the tribes of animated nature.

Autumn is the season when the fruits of the earth are brought to maturity, to supply the wants of man and beast. The silent and gradual progress of maturity is now completed,

and the promise of spring fulfilled. The fields are covered with a golden harvest, the reapers in joyful groups are cutting down their sheaves, and the productions of the earth are gathered into the garner, to be stored up as provisions for the coming year. In every garden and orchard, delicious fruits of various hues are seen hanging on the branches, to gratify the eye, the palate, and the imagination, and presenting a specimen of the superabundance of Divine goodness in providing such a variety of comforts for the human family. "Oh that men would praise the Lord for his goodness, and for his wonderful works to the children of men."—For He crowneth the year with his goodness, his "paths drop fatness:—the little hills rejoice on every side. The pastures are clothed with flocks; the valleys also are covered over with corn; they shout for joy, they also sing." Towards the close of this season, the objects of the vegetable creation begin to lose their bloom and their beauty. The groves lose their leafy honours; the gaudy flowers disappear; and nature puts on a more bleak and sombre aspect. But before the forests and the groves are stripped of their beauty, they assume a temporary splendour superior to even the verdure of spring, or the luxuriance of summer. The everchanging hues of the leaves of the trees, melting into every soft gradation of colour and shade, have long engaged the imitation of the painter, and in some measure enliven the gloom of the falling year. During this season, (on the 23d of September,) the sun crosses the equinoctial, in his course towards the south. He then sets to the north pole, and begins to diffuse his rays on the south polar regions, where spring now commences; and during all the period which intervenes from this time, till the 21st of the following March, the sun shines without intermission around the southern pole.

Winter succeeds autumn, and completes the circle of the seasons, in our northern latitude. The thickening fogs, the heavy rains, the hail showers, and the descending snows, now begin to deface the beauties of the rural landscape. The melody of birds is seldom heard in the groves; the flowers lie dead, and their beauties defaced; the trees are lashed by storms, stripped of their verdure, and spread their naked arms to the ruthless winds. The vapours sometimes thicken into an impenetrable gloom, and obscure the face of the sky. The rains descend in torrents; the brooks swell, the rivers burst their banks, and bury the meadows under a soaking deluge. The atmosphere is now and then hurled into tumultuous confusion, and every thing trembles before the furious blast. The

trees of the forest are dashed headlong to the ground, and the shepherd's cot carried aloft in the air, or shattered in pieces. The ocean swells with violent commotions, and tosses its waves towards the clouds. Ships are dragged from their anchors, and are whirled about as stubble along the vast abyss, and some of them plunged into the open gulf, with all their mariners, to rise no more. Such are some of the aspects and desolations of stern winter. But it is also accompanied with numerous benefits to mankind. The frost and cold which winter produces, prevent many hurtful vapours in the higher regions of the atmosphere from falling upon us, and purify the air from noxious exhalations. Far from being prejudicial to health, they often improve it, and prevent the humours from that putrefaction which heat might produce. Cold has a tendency to brace the animal system, and to promote the circulation of the blood. When the fields and gardens are covered with snow, this is necessary to preserve them from the cold, and to prevent the grain from corrupting. The earth requires repose, after having yielded in summer all that we require for our subsistence during the winter. While the cold continues, the means are at hand for procuring artificial heat, by the abundance of coals and wood which the Creator has provided. During this season, too, we enjoy the most brilliant and interesting views of the starry heavens, of the planets in their courses, and of the moon "walking in brightness." So that in every season, we have abundant evidence of the goodness of our bountiful Creator, and of the tender care he exercises over every portion of the human family. During the middle of winter the days are shortest and the nights the longest. This happens more particularly about the 21st of December, when the sun, in our latitude, rises near the south-east, describes a short curve a little above the southern horizon, and sets near the south-west, after having remained only seven or eight hours above the horizon.

It is here worthy of remark, that all the diversified phenomena of the seasons, and the different lengths of days and nights throughout the year, are produced by the operation of a few apparently simple principles. In all the operations of the Almighty, we find that the most diversified and astonishing effects are produced by causes that are either unheeded, or by agents which, to our limited view, appear altogether inadequate to produce the results. From the simple principle of gravitation, for example, proceed all the beauties and sublimities which arise from the meandering rills, the majestic rivers, and the roaring cataracts; it causes the mountains to

rest on a solid basis, and confines the ocean to its appointed channels; it produces the descent of the rains, and dews, and the alternate flux and reflux of the tides; it rolls the moon round the earth, and prevents her from flying off to the distant regions of space; it extends its influence from the earth to the moon, and from the sun to the remotest planets—preserving surrounding worlds in their proper courses, and connecting the solar system with other worlds and systems in the remote spaces of the universe. From the minutest atom to the vast luminaries of heaven, every thing is subject to its all-powerful influence; and from this active invisible agent proceed all the order, beauty and variety, which distinguish the works of creation. Thus, also, the principle called electricity —which manifests itself in sparks of fire, when a glass tube is rubbed in the dark—is found to be the cause which produces the lightnings of heaven, and all the sublime phenomena which accompany a violent thunderstorm; and in combination with other agents, produces likewise the fiery meteor which sweeps through the sky with its luminous train, and the beautiful coruscations of the aurora borealis.

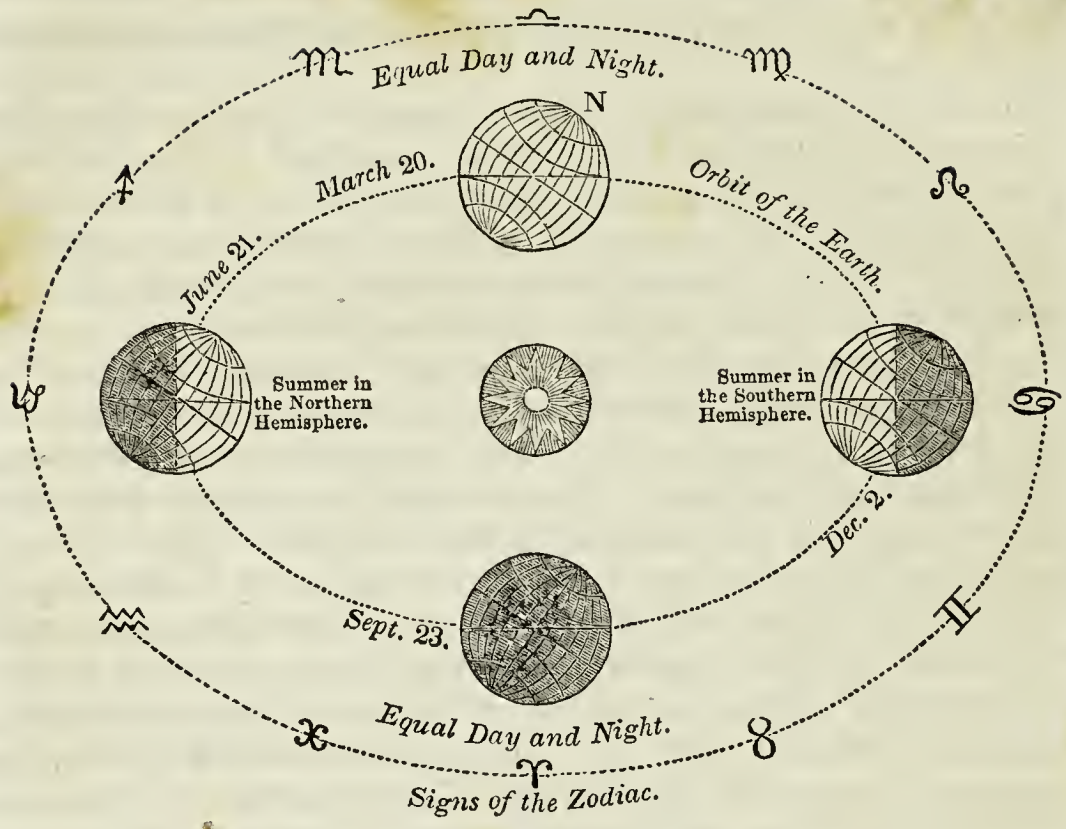
In like manner the vicissitude of day and night and the revolution of the seasons and their diversified phenomena, depend on the most simple principles and arrangements. The alternate succession of day and night is occasioned merely by the uniform rotation of the earth upon its axis. As our globe turns round on this imaginary line every 24 hours, and as only one-half of a globe can be illuminated at a time, it is evident that any particular place will sometimes be turned towards the sun, and sometimes opposite to it; and being thus constantly subjected to these various positions, a regular return of light and darkness will be experienced during the above period in every region not within the limits of the polar circles. When, by the diurnal revolution, any place is carried into the dark hemisphere, it is night; and when turned round into the enlightened hemisphere, it is day. The sun and all the other heavenly bodies appear to move along the heavens every day from east to west; but this motion is only apparent, and is caused by the real motion of the earth on its axis from west to east; but the apparent motion of these bodies is somewhat different at different seasons of the year, and in different regions of the globe. (See anté, p. 16. All the planets on whose surfaces spots have been discovered, are likewise found to perform rotations round their axes, which will produce a similar revolution of day and night, as in our world, though in different periods of time,

some of the planets finishing the periods of their rotation in about ten hours, some in ten and a half, and others in twenty-three hours.

As to the vicissitudes of the seasons—this is owing to the inclination of the earth's axis to the plane of its orbit. If the axis of the earth stood perpendicular to the plane of its orbit, there would be no variety in the length of days and nights; but they would of course be equal all over the globe, except at the poles, where the sun would neither rise nor set, but remain continually in the horizon, as he is seen at present in that position on the 21st of March and the 23d of September, at the north and south pole. This inclination is $23\frac{1}{2}$ degrees from the perpendicular, which makes an angle with the earth's orbit, or the ecliptic, of $66\frac{1}{2}$ degrees. The axis of the earth always keeps parallel to itself, in its motion round the sun, and points exactly to the same part of the heavens. This may appear somewhat strange, since the orbit of the earth is 190 millions of miles in diameter; but this extent, however great, is only as a point when compared with the immense distance of the fixed stars—the nearest of which is at least more than two hundred thousand times farther from us than we are from the sun. If we look along two parallel rods, four or five yards distant from each other, they will both seem to point directly to the moon when in the horizon, though at such a distance from each other, although they would not both point to the same object placed at a short distance. And perhaps four or five yards bear as great a proportion to the distance of the moon as 190 millions of miles bear to the distance of the stars.

The subject of the seasons may be illustrated by the following diagram, fig. 60, which represents the earth in four different positions in its orbit, the central figure representing the sun. It is known from observation that the axis of the earth is always directed to very nearly the same fixed point in the heavens, and therefore it will constantly preserve the same position, in whatever part of its orbit the earth may happen to be in its circuit round the sun, as may be seen in the figures here represented. Let us now suppose the earth to be in the situation represented at March, or at N, at the higher part of the diagram. A right line joining the centres of the earth and sun will cut the surface of the earth in the equator, and the boundary between light and darkness will pass through the two poles, and the days and nights will consequently be equal throughout the whole earth, except at the poles, which are in the boundary of light and darkness. But

Figure 60.



when the earth, in its annual course, is carried along the fourth part of its orbit to its position, as represented in June, towards the left hand of the figure, the north pole of the axis still continuing to point in the same direction, will advance into the enlightened hemisphere, and will be 23 degrees and a half from the boundary between light and darkness, and the south pole at the same distance within the dark hemisphere. It is evident that, in this position, the earth may turn round its axis a considerable number of times, and yet no places around the poles be within the boundary of darkness. And if the earth were to continue in this part of its orbit, the sun would never set to the inhabitants near the north pole, nor rise to those near the south. At the equator it would be always equal day and night; and in all places north of the equator their days would be longer and their nights shorter in proportion to their nearness to the arctic or north polar circle, while those on the south side of the equator would have their nights longer than their days.

But as the earth moves forward in its orbit towards September, represented in the lower part of the cut, the north pole will gradually approach the boundary between light and darkness, which boundary will again pass through both poles on the 23d of September; the days will gradually shorten till it arrive at this point, and day and night over the globe will be then equal as before. This is called the autumnal equinox,

and this season is a kind of medium between summer and winter. As the earth proceeds through the other quarter of its orbit, the days will still shorten till December 21st; when the north pole of the earth will be just as far in the dark hemisphere, as it was in the enlightened one on the 21st of June. This position of the earth, represented at the right-hand side of the cut, is called the winter solstice. From this period to the vernal equinox in March, the days gradually lengthen as the north pole again approaches the boundary between light and darkness; and when the earth arrives at that point, the circle of the year and of the seasons is completed. From the description now given it will evidently appear that the inhabitants of the southern regions of our globe have the same variety of seasons which we enjoy, but in a reverse order. When it is summer in southern climes, it is winter with us: and when it is spring with us, it is autumn in the southern regions.

The different signs of the zodiac through which the earth, or the sun, passes in the course of the annual revolution are depicted in their several characters, in the outer circle of the diagram. They are as follows:—beginning at the bottom, at September, and proceeding towards the right hand, Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquarius, Pisces. These are the names of the twelve constellations through which the sun apparently passes in the course of a year. In March, the real place of the earth is Libra, and consequently the sun will appear in the opposite sign in Aries, and be vertical to the equator. In June, the earth is in Capricorn and the sun in Cancer, when he is vertical to those who live under the tropic of Cancer. In September, the earth is in Aries and the sun in Libra, when he is again vertical to the equator. In December, the earth is in Cancer and the sun in Capricorn, when he is vertical to those living under the tropic of Capricorn; as the inhabitants of South Africa and the central parts of New Holland. The explanations now given of the seasons would, perhaps, appear more perspicuous to the astronomical tyro, were they to be illustrated by an orrery, a tellurian, or any other instrument calculated to elucidate the subject.

In the northern part of the globe, where we reside, our summer is nearly eight days longer than our winter. By summer, we understand the time which elapses between the 21st of March and the 23d of September; and by winter, the time between the 23d of September and the 21st of March; or the period between the autumnal and vernal equinoxes.

In the former case, the earth passes through 184 degrees of its orbit, which occupies 186 days, 11 hours; in the latter case it passes through only 176 degrees, which is performed in 178 days, 18 hours. The reason of this difference is, that the earth moves in an elliptical orbit, one portion of which is nearer the sun than another; in consequence of which the sun's apparent motion is slower when in the northern signs than while it traverses the southern ones. This orbit is more than three millions of miles longer in one direction than it is in another; consequently, the sun is farther from us at one season than he is at another. On the 1st of January he is three millions of miles nearer us than on the 1st of July, which is ascertained from the difference of his apparent diameter at those seasons. On the 1st of January his apparent diameter is 32 minutes, 35 seconds, whereas, on the 1st of July, he is only 31 minutes, 31 seconds,—being a difference of 1 minute of a degree and 4 seconds.

Here a question will naturally occur,—Why have we the coldest weather when the sun is nearest us, and the hottest when he is farthest distant? This is owing to various causes; the principal of which is, that the sun's rays in winter fall so obliquely upon us, and have so large a portion of the atmosphere to pass through, that they come with less force, and spread over a larger space than they do in the summer, when the sun is at a greater height above the horizon. Besides, in the long nights of winter, we have a greater degree of cold than can be compensated by the return of heat in the short days, by reason of which the cold will be increased till the days sensibly lengthen. On the other hand, the greater length of the day contributes to augment the heat in summer; for the earth and air are heated by the sun in the day-time more than they can be cooled in the night, and on this account the heat will go on increasing in summer till the days sensibly decline. In summer, too, the sun rises to a high altitude, and his rays pass through a much less portion of the atmosphere, and are less refracted and weakened by it than when they fall more obliquely on the earth, and pass through the dense vapours near the horizon. Hence it is, that it is colder near the time of sunset, and a little after sunrise, than when the sun is near his meridian altitude. It is owing to these and similar circumstances that the hottest and coldest seasons of the year are not about the time of the longest and shortest days, but generally about a month after these periods. For a body once heated does not grow cold instantaneously, but gradually; and so long as more heat comes from the sun

in the day than is lost in the night, the heat will gradually increase till it comes to a certain maximum, when the increasing length of the night will cause it to diminish.

The subject of the seasons has been a favourite theme to poets as well as to philosophers; and they have frequently expatiated on the beauties and the beneficent designs connected with the varying aspects of the revolving year. And it must be admitted that, in the present constitution of our globe, and in the present moral state of the human race, there are many advantages enjoyed, and much of the Divine goodness is displayed in every one of the seasons as they successively appear, which brings along with it its peculiar beauties, pleasures, and enjoyments. But the earth, with the seasons as they now "roll," can scarcely be considered as an abode suited to an innocent creature that has retained its original purity and integrity;—the burning heats in summer, which are felt in the southern climes, the whirlwinds, tornadoes, inundations, thunders and lightnings, with which they are frequently accompanied; and the frosts and snows, storms and tempests, and insufferable cold which are felt in winter in different parts of the temperate climates, and in the polar regions—seem to be accommodated only to beings who are involved in guilt and tainted with moral depravity; and, therefore, we have no reason to believe that the seasons, as they now exist, would have presented the same aspects, or operated in the same manner, had man remained in his primeval innocence and allegiance to his Maker. A great change seems to have taken place in this and other respects at the period of the universal deluge, when the "fountains of the great deep" were broken up, the cataracts of heaven opened, and the solid strata of the earth scattered and disrupted: then, in all probability, the constitution of the atmosphere likewise underwent an extensive change as to its composition and properties, which is partly the cause of some of those storms and tempests and other phenomena which arise in the course of the revolution of the seasons. But, even in the present state of nature, we have reason to be grateful to God, that in all his dispensations towards his creatures "he remembers for us mercy in the midst of deserved judgment"—that while hurricanes, tempests, and earthquakes sometimes produce dreadful devastations, and sweep away multitudes of human beings from the living world, "his tender mercies" may be said, on the whole, to be diffused "over all his works;" for every season of the year brings along with it its own peculiar enjoyments, in a thousand different ways; and man, even in

his present condition, might be a comparatively happy being, were his thoughts and affections, his temper and actions, regulated by the principles and precepts of Christianity and the moral laws of his Creator. The evil passions and depraved affections which prevail among mankind, are far more destructive to human happiness than all the storms and tempests, thunders and lightnings, earthquakes and volcanoes, that rage throughout the seasons and convulse the elements of nature.

The present state of man on earth, in the midst of the circling seasons, appears to be adapted only to a being who has but a short time to remain in this terrestrial sphere; whose aim ought to be to aspire after a nobler scene of existence—to enter in the prescribed path to this happier state, by believing in the name of the only begotten Son of God, who is "the Way, the Truth, and the Life"—and by cultivating, with vigilance and caution, those heavenly tempers and Divine virtues which will prepare him for the employments of an immortal existence. As the engagements of life and religion are such as human nature does not always willingly perform, and is apt to postpone them to what it considers a more convenient season—the vicissitudes of the seasons, and other arrangements in nature, have a tendency to stimulate us in the performance of present duty. Whatever we behold in the economy of nature around us, reminds us of the lapse of time and the flux of mortal existence. The day and night regularly succeed each other, and remind us that a certain portion of duration has fled. The sun appears in the eastern horizon; he soon attains his meridian altitude, then declines, and in a few hours sets in the west;—the stars in their courses mark the lapse of our fleeting moments;—the moon does the same every night, by changing its form; and the revolution of the seasons diversifies the year, and shows how large a portion of human life glides silently away. If the wheel of life passed on in undistinguishable uniformity, we should scarcely be able to mark its approaches to the end of the course. If one hour were uniformly like another—if the diurnal motion of the sun did not show that another day is on the wing—if the circling seasons did not impress us with the flight of another year—quantities of duration, equal to days, months, and years, might glide away without being observed, and without improvement. But the course of time, marked out by so many movements, objects and circumstances, continually reminds us of what progress we have made in gliding down the stream of life towards the ocean of

eternity! and admonishes each of us by its rapidity, "Whatsoever thy hand findeth to do, do it with thy might," since the day rolls on, and "the night cometh, when no man can work."

In fine, the several divisions of the seasons have been considered as bearing a striking analogy to the course of human existence. Spring has been represented as the youth of the year, the season of pleasing hope, blooming beauty, and lovely energy. Summer has been likened to perfect manhood, the season of confirmed strength, and persevering vigour. Autumn has been compared to that period when man is mellowed by age and brings forth the fruits of wisdom and experience. And cheerless Winter has been termed the decrepit and hoary old age of the year. If a day be considered as an image of a year, and the year as a representation of human life—then the morning answers to spring, and the spring to childhood and youth; the noon corresponds to summer, and the summer to manhood. The evening is an emblem of autumn, an autumn of declining life; the night is an emblem of winter, in which the powers of vegetation are benumbed,—and winter points out the time when life shall cease, with all its hopes and joys. With such views, Thomson, the poet of the "Seasons," closes his description of Winter:

——————— Behold, fond man!
See here thy pictured life: pass some few years,
Thy flowering Spring, thy Summer's ardent strength,
Thy sober Autumn fading into age,
And pale concluding Winter comes at last,
And shuts the scene. Ah! whither now are fled
Those dreams of greatness? those unsolid hopes
Of happiness? those longings after fame,
Those restless cares, those busy bustling days?
Those gay spent festive nights? those veering thoughts
Lost between good and ill that shared thy life?
All now are vanish'd! Religion sole survives,
Immortal, never-failing friend of man,
His guide to happiness on high!

CHAPTER VIII.

REFLECTIONS, MORAL AND RELIGIOUS, IN REFERENCE TO THE SOLAR SYSTEM.

WITHOUT entering at present on the consideration of any other topics connected with astronomical science, we shall conclude the present work with a few reflections, suggested by the subject we have endeavoured to illustrate in the preceding pages.

The science of astronomy presents to our view objects which are calculated to raise our admiration, and to excite the soul to solemn reflection, and elevated contemplations. When we take but a cursory view of the nocturnal heavens, in a clear and serene evening, we are almost irresistibly overpowered with emotions of wonder and awe, at the amazing grandeur of the vast canopy around us, and the number of the brilliant orbs which shed their radiance upon us from afar. But when, with the eye of the intellect, assisted by the telescope and the discoveries of science, we endeavour to traverse the immense spaces above us, and to survey the number, the magnitude, the distances, and the rapid motions of the globes dispersed throughout the regions of immensity, we are completely overpowered, and lost in astonishment, at the extent and grandeur of the scene—their numbers cannot be told; their magnitude cannot be conceived; their distances are beyond human calculation and comprehension; and the amazing velocity with which they fly through the regions of space is confounding and almost terrifying to the imagination. Millions upon millions of those magnificent globes have been running their ample rounds for thousands of years, and will, doubtless, continue their courses, though amidst numerous changes, throughout all the revolutions of eternity. The immense forces with which they are impelled in their career; the magnificent circles they describe; the beautiful order in which they are arranged; the regularity and harmony of their movements; and the noble and important ends to which they are destined, proclaim, in language not to be mistaken, that "the Hand that made them is Divine;" and, therefore, that they ought to be studied, and contemplated with pious emotion, by every rational and religious mind:

"Come forth, O man! yon azure round survey,
And view those lamps which yield eternal day.
Bring forth thy glasses; clear thy wondering eyes;
Millions beyond the former millions rise;
Look further;—millions more blaze from yonder skies."

Who can look up to the midnight sky, and behold its rolling wonders, without being struck with astonishment at the idea of that great Being, who formed such vast and magnificent works? "Canst thou by searching find out God? canst thou find out the Almighty unto perfection?" There is a length and a breadth, a heighth and a depth, in the perfections of the Divinity, which finite intelligences will never be able fully to comprehend. Vast and magnificent as the structure of the starry heavens is, it was produced without materials—it emerged out of nothing. The voice of the Eternal "spake, and it was done." "He commanded," and the orbs of the firmament started into being. "Let there be light: and there was light." "By the word of the Lord were the heavens made; and all the host of them by the breath of his mouth." Our admiration of such wonderful works should lead us to humble ourselves in his august presence, and to reverence and adore him as the uncreated source of all felicity. "Let all the earth fear the Lord; let all the inhabitants of the world stand in awe of him."

But as we have not yet taken a survey of the starry heavens, and the wonderful scenes which they disclose, we shall chiefly confine our present reflections to the objects connected with the planetary system, of which we have given a brief sketch in the preceding pages.

In the first place, when we contemplate the grand machinery of the solar system, we are presented with a striking display of the almighty power of Him who formed it. It presents to our view objects of overpowering magnitude and grandeur—planetary globes, a thousand times larger than the earth; and magnificent rings, which would reach nearly from the earth to the moon, and which would enclose within their vast circumference four hundred worlds as large as that on which we dwell. It exhibits a sun more than twelve hundred thousand times larger than our earthly ball, and five hundred times larger than all the planets, their satellites and rings, taken together, even although hundreds of comets were also included; and this sun extending his influence to bodies a thousand millions of miles distant, enlightening them by his beams, and retaining them in their orbits by his attractive influence. It presents before us motions, so astonishing as to overpower all our faculties—bodies, a thousand times larger

than our globe, flying with a velocity of thirty thousand miles every hour, carrying along with them a retinue of revolving worlds, and continuing their rapid career, without a moment's intermission, for thousands of years—nay, motions at the rate of eight hundred thousand miles an hour have been perceived among some of the bodies connected with the solar system.

What a striking display do such objects present of the power and grandeur of Omnipotence, so frequently celebrated by the inspired writers. "Great is our Lord, and of great power: his understanding is infinite; his greatness is unsearchable;" wonderful works doth He, which we cannot comprehend. "Who is a strong Lord like unto thee? Who in heaven can be compared unto the Lord? Who among the sons of the mighty can be likened unto the Lord?" We are sometimes apt to be dazzled with the splendour of riches, and to admire, in the palaces of the great, the magnificence of the furniture, the beauty of the apartments, and the profusion of gold and silver ornaments that appears on every side. We are apt to reverence mighty potentates, when they bear rule over multitudes of subjects, and exercise their sway over extensive countries. We judge of the greatness of men by their actions, when they build spacious cities, and erect splendid palaces and temples; when they construct steam-engines and carriages, and impel them forward with a motion of fifty miles an hour. But, what are all the powers and energies of man, as displayed in his noblest achievements, compared with the magnificence and energies displayed throughout the planetary system? What are a few cities, palaces, and temples, compared with the grandeur and extent of mighty worlds? What is a small corner of the earth, compared with the expansive range over which the sun extends his influence? What is the motion of a small engine, even at fifty miles an hour, compared with the motion of a globe ten thousand miles in circumference, flying at the rate of a hundred thousand miles an hour? All human art, power, and grandeur must hide their diminished heads in the presence of Him who is the former and governor of spacious worlds. As the splendour of the stars is absorbed by the rays of the sun, so all the grandeur, power, and splendour of this world and its inhabitants vanish before the presence of Him who is "the King Eternal, Immortal, and Invisible," and before whom "all nations are accounted as nothing, and less than nothing and vanity." And, if such power is displayed in one sun, and one system of revolving worlds, how great beyond conception the effects of that Almighty energy

which has brought into existence thousands and millions of other suns and systems, and dispersed them in countless numbers throughout the illimitable tracts of space! "Who can utter the mighty acts of the Lord?"—"Great and marvellous are thy works, Lord God Almighty!"

This attribute of the Almighty, so conspicuously displayed in the heavens, lays a sure foundation for the faith and hope and comfort of the Christian, amidst all the perplexities and afflictions to which he is subjected in the present state. For it assures him that whatever Jehovah has promised, "he is able also to perform." The promises addressed to us by a wise and benevolent Being can excite in us hope and dependence, only in so far as we are convinced of his power to secure their accomplishment. If omnipotence were not an attribute of the Divine Being, or were we unable to trace its operations in existing facts, we could have no rational dependence on his promises and declarations in regard to objects which are unseen and eternal, and which lie beyond the limits of human comprehension. But when we behold, in the arrangements of this lower world, and in the solar system, a display of omnipotent energy in incessant operation, far beyond the grasp of our limited faculties, we plainly perceive that there is not a promise recorded in Divine revelation, nor a future fact declared, but is within the power of Jehovah fully to accomplish and realize. "He doeth according to his will in the army of heaven, and among the inhabitants of the earth: and none can stay his hand, or say unto him, What doest thou?" Should afflictions assail us, he is able to comfort and support. Should calamities befal us, or dangers surround us, he is able to deliver. Should death stare us in the face, and heart and flesh begin to faint and fail, he is able to transport our spirits to a nobler scene of existence, and to re-animate our mortal frames at the resurrection of the just. Happy, then, is the man who hath this eternal God for his refuge, "whose hope is in the Lord his God: which made heaven and earth, the sea, and all that therein is: which keepeth truth for ever." For He "is able to do exceeding abundantly above all that we can ask or think," "according to the working of his mighty power, which he wrought in Christ, when he raised him from the dead, and set him at his own right hand in the heavenly place."

2. The arrangements of the solar system display the wisdom and benevolence of its Creator. Were it possible to conceive a being possessed of such power as the planetary system displays, but devoid of wisdom and goodness, such a

being would be the most terrible object which the human mind could contemplate. Power acting at random, without regard to the happiness of intellectual beings, could only produce terror and apprehension throughout the intelligent universe, uncertain whether or not its energies might be exerted for the purpose of promoting misery and destruction. But the attribute of omnipotence, when conjoined with infinite wisdom and boundless benevolence, conveys an idea the most glorious and transporting; and these perfections are conspicuously displayed throughout all the works of God. His wisdom is illustriously displayed in the arrangements of the planetary system, in placing near the centre of this system that immense luminary, the sun, from whence light and heat might be distributed in due proportions to all the worlds that roll around it—in nicely proportionating the motions and distances of all the planets, primary and secondary—in uniting them in one harmonious system by one grand and universal law, which prevents them from flying off in wild confusion through the infinity of space—in nicely adjusting the projectile velocity to the sun's attractive power, so as to produce harmony of motion, and to prevent the planets, on the one hand, from rushing forward to the sun, and, on the other, from flying off in a tangent through the regions of immensity—in the constancy and regularity of their motions, no one interfering with another or deviating from the course prescribed—in the exactness with which they run their destined rounds, finishing their circuits with so much accuracy as not to deviate from their periods of revolution the space of a minute in a hundred years—in the spherical figure given to all these mighty orbs, and the diurnal motions impressed upon them, by which a due proportion of light and heat is diffused over every part of their surfaces—and in the wonderful simplicity of the physical laws, on which so much beauty, harmony, and order depend. In all these and many other respects, the planetary system presents a display of "the manifold wisdom of God."

The benevolence of the Deity is likewise manifested throughout this system, in ordering all the movements and arrangements of the planetary globes, so as to act in subserviency to the comfort and happiness of sentient and intelligent beings. For the wisdom of God is never employed in devising means without an end: and the grand end of all his arrangements, so far as our views extend, is the communication of happiness; and it would be inconsistent with the wisdom and other perfections of God not to admit that the same end is kept in view in every part

of his dominions, however far removed from the sphere of our observation. We cannot, indeed, explore the minute displays of Divine goodness in the distant regions of the planetary system, but we perceive certain general arrangements which clearly indicate that the happiness of intellectual natures is one of the grand ends of the Divine administration. For example—light is essential to the comfort and happiness of all living beings. Its rays illumine the vast expanse of the heavens, and unveil all the beauties and sublimities of creation around us. Without its influence the universe would be transformed into a desert, and happiness, even in the lowest degree, could scarcely be enjoyed by any sentient or perceptive existence. Now we find, in the arrangements of the solar system, that ample provision has been made for diffusing light in all its varieties over every planet and satellite belonging to this system. All the planets revolve round their axes, in order that every part of their surfaces may enjoy a due proportion of the solar rays: around the more distant planets, an assemblage of moons has been arranged to throw light upon their surfaces in the absence of the sun. And while the satellites perform this office, the primary planets reflect a still greater quantity of light upon the surface of the satellites: and one of these planets is invested with a splendid double ring, of vast dimensions, to reflect the solar rays during night both on the surface of the planet and on the surface of its moons; all which arrangements must necessarily have a respect to the enjoyment of intellectual natures: otherwise they would be means without an end, which would be inconsistent with the wisdom and intelligence of the Deity. If, then, the happiness of various orders of intelligent beings was intended to be promoted by such adaptations and arrangements, we have here presented to our view a most glorious display of the expansive benevolence of that almighty Being who "is good to all," and whose "tender mercies are diffused over all his works." If this earth on which we dwell "is full of the goodness of the Lord;" if countless myriads of living beings, from man downwards to the minutest insect, are supported and nourished by the Divine bounty, how wide and expansive must be the emanations of that beneficence which extends its regards to worlds a thousand times more extensive and populous than ours! The benevolence of the Deity may be said to constitute his whole moral character, and to reflect a radiance on all his other perfections. Hence, in the records of inspiration, the Divinity is summarily described by this perfection alone, "God is love!" He is the uncreated source

of all the happiness enjoyed by every rank of spiritual and perceptive existence, from the highest angel to the worm. "O give thanks unto the Lord; for he is good: for his mercy endureth for ever."

3. The survey we have taken of the solar system has a tendency to moderate the pride of man and to promote humility. Pride is one of the distinguishing characteristics of puny man, and has been one of the chief causes of all the contentions, wars, devastations, systems of slavery, and ambitious projects which have desolated and demoralized our sinful world. Yet there is no disposition more incongruous to the character and circumstances of man. Perhaps there are no rational beings throughout the universe among whom pride would appear more unseemly, or incompatible than in man, considering the situation in which he is placed. He is exposed to numerous degradations and calamities, to the rage of storms and tempests, the devastations of earthquakes and volcanoes, the fury of whirlwinds, and the tempestuous billows of the ocean, to the ravages of the sword, famine, pestilence, and numerous diseases; and at length he must sink into the grave, and his body must become the companion of worms! The most dignified and haughty of the sons of men are liable to these and similar degradations, as well as the meanest of the human family. Yet, in such circumstances, man—that puny worm of the dust, whose knowledge is so limited, and whose follies are so numerous and glaring—has the effrontery to strut in all the haughtiness of pride, and to glory in his shame.

When other arguments and motives produce little effect on certain minds, no considerations seem likely to have a more powerful tendency to counteract this deplorable propensity in human beings, than those which are borrowed from the objects connected with astronomy. They show us what an insignificant being—what a mere atom, indeed, man appears amidst the immensity of creation! Though he is an object of the paternal care and mercy of the Most High, yet he is but as a grain of sand to the whole earth, when compared to the countless myriads of beings that people the amplitudes of creation. What is the whole of this globe on which we dwell compared with the solar system, which contains a mass of matter so many millions of times greater? What is it in comparison with the hundred millions of suns and worlds which, by the telescope, have been descried throughout the starry regions? What, then, is a kingdom, a province, or a baronial territory, of which we are as proud as if we were the lords of the uni-

verse, and for which we engage in so much devastation and carnage? What are they, when set in competition with the glories of the sky? Could we take our station on the lofty pinnacles of heaven and look on this scarcely distinguishable speck of earth, we should be ready to exclaim with Seneca, "Is it to this little spot that the great designs and vast desires of men are confined? Is it for this there is so much disturbance of nations, so much carnage, and so many ruinous wars? Oh folly of deceived men, to imagine great kingdoms in the compass of an atom, to raise armies to decide a point of earth with the sword!" Soon may the time arrive when the prophecy shall be fulfilled:—

"The wolf shall dwell with the lamb,
And the leopard shall lie down with the kid;
And the calf and the young lion and the fatling together;
And a little child shall lead them.
And the cow and the bear shall feed;
Their young ones shall lie down together:
And the lion shall eat straw like the ox.
And the sucking child shall play on the hole of the asp,
And the weaned child shall put his hand on the cockatrice' den.
They shall not hurt nor destroy in all my holy mountain:
For the earth shall be full of the knowledge of the Lord,
As the waters cover the sea.
And in that day there shall be a root of Jesse,
Which shall stand for an ensign of the people;
To it shall the Gentiles seek:
And his rest shall be glorious."

Isa. xi. 6—10.

It is unworthy the dignity of an immortal mind to have its affections absorbed in the vanishing splendours of earthly grandeur, and to feel proud of the paltry possessions and distinctions of this sublunary scene. To foster a spirit of pride and vain-glory in the presence of Him "who sitteth on the circle of the heavens," and in the view of the overwhelming grandeur and immensity of his works, is a species of presumption and arrogance, of which every rational mind ought to feel ashamed: and, therefore, we have reason to believe, that those multitudes of fools, "dressed in a little brief authority," who walk in all the loftiness of pride, have not yet considered the rank they hold in the scale of universal being—and that a serious and profound contemplation of the immensity of creation would have a tendency to convince us of our ignorance and nothingness, and to humble us in the dust in the presence of the Former and Preserver of all worlds. We have reason to believe that the most exalted beings in the universe—those who are furnished with the most capacious powers, and who have arrived at the greatest

perfection in knowledge—are distinguished by a proportional share of humility; for in proportion as they advance in their surveys of the universal kingdom of Jehovah, the more will they feel their comparative ignorance, and be convinced of their limited faculties, and of the infinity of objects and operations which lie beyond their ken. At the same time, they will feel that all the faculties they possess were derived from Him who is the original Fountain of existence, and are continually dependent for their exercise on his sustaining energy. Hence we find that the angelic tribes are eminently distinguished for the exercise of this heavenly virtue. They "cover their faces with their wings," in the presence of their Sovereign, and fly with cheerfulness at his command to our degraded world, "to minister to them who shall be heirs of salvation," and to execute whatever purposes he prescribes.

Throughout the sacred records pride is uniformly represented as abhorrent in the sight of the Almighty, while humility is marked with his approbation. "Every one that is proud in heart is an abomination to the Lord." "God resisteth the proud, but giveth grace unto the humble." "Thus saith the high and lofty One, who inhabiteth eternity, whose name is Holy: I dwell in the high and holy place, with him also that is of an humble and contrite spirit, to revive the spirit of the humble, and to revive the heart of the contrite ones." This is a consideration which deserves the serious attention of young men when they first set out in their pursuit of science. They are apt to be puffed up with a vain conceit of their acquirements, when they have acquired only a smattering of learning, and have scarcely entered the porch of the temple of knowledge, and to vaunt themselves as if they were raised to a high elevation above the vulgar throng. Let such remember that even the illustrious Newton, after the vast acquirements he had attained, and the noble discoveries he had made, when he approached the hour of his dissolution, declared, "I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the sea-shore, and diverting myself with now and then finding a pebble or a prettier shell than ordinary, while the great ocean of truth lay all undiscovered before me."

4. The subjects of astronomy to which we have directed the attention of the reader, afford a striking view of the condescension of the Divine Being towards man, especially in regard to the redemption of our fallen world. This sentiment seems to have been deeply impressed upon the mind of the psalmist, when contemplating the nocturnal heavens. View-

ing the resplendent orbs everywhere around him in the canopy of the sky—the moon displaying her radiance—the planets in their courses, and the innumerable host of stars—his thoughts seem to have taken a flight into the regions of immensity, and by the guidance of his rational powers, and the assistance of the Spirit of inspiration, he takes an expansive view of the multitude, the magnitude, and the grandeur of those magnificent globes which roll in the distant tracks of creation. Overwhelmed with his views of the immensity of the universe, and of the perfections and grandeur of its Creator, he breaks out in the language of astonishment and wonder, "When I consider thy heavens, the work of thy fingers, the moon, and the stars which thou hast ordained; what is man that thou art mindful of him? and the son of man that thou visitest him?" Surveying with his intellectual eye the boundless extent of God's universal empire, he shrinks as it were into nothing, and seems almost afraid lest he should be forgotten or overlooked amidst the immensity of beings over which the Divine government extends. And when he considered himself as a guilty creature in the presence of the Most High, his astonishment at the Divine condescension and grace must have been increased.

In no dispensation of the Almighty is this Divine condescension so strikingly displayed as in the economy of our redemption. Though countless myriads of worlds and intelligences are under his superintendence, and are incessantly celebrating his praise in the loftiest strains; and, consequently, though all the apostate inhabitants of our world might have been for ever annihilated without being missed amidst the immensity of creation, yet, amazing to relate! the joyful announcement was made to our rebellious race, "God so loved the world, that he gave his only begotten Son, that whosoever believeth in him should not perish, but have everlasting life." Soon after the fall of man this glorious intelligence was announced; and in every succeeding age God raised up a succession of prophets to announce the coming of the great Deliverer, "to foretell the sufferings of Christ, and the glory that should follow." And when the time appointed in the decree of Heaven arrived, the promised Messiah was at length ushered into the world. A messenger from the celestial world, surrounded with refulgent splendour, was despatched to the plains of Bethlehem, to make known his appearance in the world: "Behold," says he, "I bring you good tidings of great joy, which shall be to all people. For unto you is born this day in the city of David, a Saviour, which is

Christ the Lord." And immediately a multitude of angels, having winged their flight from their heavenly mansions, joined in a chorus of congratulation and praise, "Glory to God in the highest, and on earth peace, good will toward men." Our Redeemer having passed through the scene of his public ministry, and manifested himself to be "the Son of God with power," by a series of beneficent miracles, which he performed in every region of the land of Judea—was "led as a lamb to the slaughter," delivered up to the severest sufferings for our sake, and "became obedient unto death, even the death of the cross!" And while he hung on the accursed tree, the most awful and striking miracles were exhibited to surrounding spectators, in order to display the dignity of Him who suffered, and the importance of that "decease which was accomplished at Jerusalem." The sun was clad in black, the heavens were arrayed in sackcloth, the day was turned into night, and, for three hours, darkness covered the whole land. The rocks rent asunder, the foundations of the earth did quake, the veil of the temple was rent in twain from the top to the bottom, the graves were opened, and many bodies of the saints who slept arose.

This was the most wonderful event, and the most illustrious display of Divine love that was ever announced to our world. What displays of Divine love and mercy may have been made to other worlds, and other orders of beings, we are not in a situation to determine. We dare not affirm that, in other regions of the Divine empire, similar displays have not been made; for we have never traversed the depths of immensity to ascertain all the dispensations of the Almighty in every province of creation. But we may boldly affirm that the mission and the death of Christ were the most wonderful events, and the most astonishing displays of mercy and love that were ever made to our sublunary world. As the apostle of the Gentiles has declared, there is a height and a depth, a breadth and a length in the love of God which is in Christ Jesus, that passeth knowledge. When we consider the depths of misery from which it raises us, the heights of felicity to which it exalts us, the boundless nature of its operations, and the everlasting continuance of all its blessings, we have reason to exclaim, in the language of admiration, with the apostle John, "Behold, what manner of love the Father hath bestowed upon us that we should be called the sons of God!" "Unto him that loved us, and washed us from our sins in his own blood, and hath made us kings and priests

unto God and his Father; to him be glory and dominion for ever and ever!"

5. The studies connected with the science of the heavens have a tendency to prepare the soul that has been previously enlightened and regenerated, for the employments of the future world. In that world the glory of the Divine perfections, as manifested throughout the illimitable tracks of creation, is one of the objects which unceasingly employ the contemplations of the blessed; for they are represented in their adorations, as celebrating the attributes of the Deity as displayed throughout the material universe: "Great and marvellous are thy works, Lord God Almighty. Thou art worthy, O Lord, to receive glory and honour and power; for thou hast created all things, and for thy pleasure they are and were created." Before we can enter that world and mingle with its inhabitants, we must acquire a relish for their employments and some acquaintance with the objects which form the subject of their sublime investigations; otherwise we could feel little enjoyment in the society of heavenly intelligences, and the exercises in which they engage. The investigations connected with astronomy, and the frequent contemplation of its objects, may tend to prepare us for such celestial employments; as they awaken attention to such subjects—as they invigorate the faculties and enlarge the capacity of the intellect—as they suggest sublime inquiries, and excite desires for further information which may afterwards be gratified—as they form the ground-work of the progress we may afterwards make in that state, in our surveys of the Divine operations—and as they habituate the mind to take large and comprehensive views of the empire and moral government of the Almighty.

Those who have made progress in such studies, under the influence of holy dispositions, will certainly have higher and more perfect conceptions of the attributes of Jehovah than those who have given little or no attention to them; and it is not perhaps an unwarrantable supposition, that by such employments as most familiarize us with the glorious works of the Creator, and lead us to the contemplation of his moral perfections, we may be the better prepared for directing the views and investigations of such as have enjoyed fewer opportunities of instruction in the present state. For, we are informed in the sacred records, that "they who are teachers of wisdom shall shine as the brightness of the firmament, and they that turn many to righteousness as the stars for ever and ever:" plainly intimating, that those who have made eminent

advances in Divine knowledge, and applied it to its proper use, shall be distinguished with peculiar honours.

It is here of some importance to remark, that it is not merely a scientific view of the mechanical fabric of the universe that will prepare us for the employments of the celestial world, but the moral principles and the holy affections with which we are animated in all our studies and contemplations. A man under the influence of evil principles and passions, whose mind is actuated by pride, malignity, avarice, or revenge, is unqualified for a right contemplation of the works of God, for joining in the associations of pure and holy beings, and for engaging in the exalted services of the heavenly world. Unless the principles of "love to God" and "love to man" be engraven on our hearts, and interwoven throughout the whole of our mental frame, and manifested in the general tenor of our conduct, we can never enjoy true happiness either in the present state or in any other region of the universe; and such principles and dispositions can never be expected to be implanted in the soul, and brought forth into action, unless we comply with the requisitions contained in the word of God. The foundation of future felicity must be laid in "repentance toward God, and faith toward our Lord Jesus Christ." As sinners against the most high God we stand in need of pardon, peace, and reconciliation. And "this is the record of God, that he hath given to us eternal life, and this life is in his Son." "This is his commandment, that we believe on the name of his Son Jesus Christ,—whom God hath set forth to be a propitiation, to declare his righteousness for the remission of sins."

This is the first step in the path which leads to life eternal. And having entered on this course, we must be careful to bring forth "the fruits of righteousness," and to "glorify God in our bodies and spirits which are his." We must "add to our faith virtue; and to virtue knowledge; and to knowledge temperance; and to temperance patience; and to patience godliness; and to godliness brotherly kindness; and to brotherly kindness charity. For if these things be in us and abound," we shall neither "be barren nor unfruitful in the knowledge of our Lord Jesus Christ. For so an entrance shall be ministered unto us abundantly into the everlasting kingdom of our Lord and Saviour Jesus Christ." Prosecuting such a course with activity and perseverance, holding communion with the "Father of our spirits," and exhibiting a pattern of every Divine virtue and grace, we shall enjoy all that happiness which is consistent with our present state of

trial and imperfection, and be gradually prepared for being "partakers of the inheritance of the saints in light:" where there is "fulness of joy," and "pleasures for evermore." In short, animated by such Divine principles and affections, we shall be fitted for holding intercourse with all the holy beings that constitute the moral and intelligent system, or the whole family of God throughout the universe, in whatever regions of the vast creation they may reside; for the principles and dispositions to which we have adverted must be common to all the pure intelligences that people creation, that have retained their primeval innocence and rectitude. When implanted in the heart, and interwoven through the whole of the mental constitution, they assimilate us to angels and every other class of holy intelligences, and qualify us for associating with the superior orders of intellectual natures—for entering into their sublime and comprehensive views—for bearing a part in their extensive schemes of universal beneficence—and for contributing along with them to the order and prosperity of God's universal and everlasting kingdom!

APPENDIX.

I.

NEW DISCOVERIES IN THE PLANETARY SYSTEM.

THE PLANET NEPTUNE.—The discovery of this planet forms a remarkable era in the history of astronomy. It was ascertained to exist by calculations founded on the principles of physical astronomy, and on the discrepancies which were found to exist between the observed and the calculated places of *Uranus*. It was conceived that probably some disturbing body existed beyond that planet, which had hitherto eluded the observation of astronomers, and which produced the irregularities to which we allude. The following is a brief sketch of the history of this discovery:—

The Rev. Dr. Hussey, in 1834, wrote to Professor Airy, of the Royal Observatory, Greenwich, that he conjectured the possibility of some disturbing body beyond Uranus, and that he had found that Bouvard and Hansen had been in correspondence on a similar conjecture. In 1842, the late distinguished astronomer, Bessel, in conversation with Sir John Herschel, in reply to the question whether the deviations in question might not be due to the actions of an unknown planet, stated, that he thought it highly probable that such was the case. But, till September, 1845, there was not produced by any astronomer a research that was calculated to decide this question. It was about this time that Mr. J. C. Adams, fellow and assistant of St. John's college, Cambridge, communicated to Professor Challis, of the Cambridge Observatory, values which he obtained for the heliocentric longitude, eccentricity of orbit, longitude of perihelion, and mass of an assumed exterior planet, deduced entirely from unaccounted-for perturbations of Uranus. The same results, somewhat corrected, were left at the Observatory of Greenwich, about the end of the following October, in a paper containing the following statement:—"According to my calculations, the observed irregularities in the motion of Uranus may

be accounted for, by supposing the existence of an exterior planet, the mass and orbit of which are as follows :—

Mean distance (assumed nearly in accordance with Bode's law)	30.84
Mean sidereal motion in 365¼ days	1° 30.′9
Mean longitude, 1st October, 1845	323° 34′
Longitude of perihelion	315° 55′
Eccentricity	0.1610
Mass, that of the sun being unity	0.0001656

These were the first intimations of the new planet that were ever made public; and at, or near the position here assigned to it, it was afterwards seen by Professor Challis of the Cambridge Observatory. Had Mr. Airy attended to the above, as he ought to have done, Mr. Adams would have enjoyed the undivided merit of being the first discoverer of this planet; and we cannot but feel indignant at the apathy and neglect of the Royal Astronomer, especially when we consider that Mr. Adams made two journeys to Greenwich to explain this matter, and left his papers and calculations at the Observatory.

In the *Comptes Rendus*, for June 1, 1846—eight months after Mr. Adams had made known the elements of the new planet's orbit to the English astronomers—M. Le Verrier gave a memoir on the theory of Uranus, in which he affirmed the necessity of admitting the hypothesis of an exterior planet. No elements of the orbit or *mass* were given, but its longitude, it was stated, should be, for the beginning of 1847, about 325°. He communicated his principal conclusion to the astronomers of the Berlin Observatory on September 23d, and, guided thereby, and comparing the observations with a star map, M. Galle found the planet on the same evening.

Professor Challis, before this time, in consequence of a laborious research, had actually seen the planet. On July 30th, he went over a zone of the heavens, nine minutes broad, in such a manner as to include all stars up to the eleventh magnitude. On August 4th, he took a wider zone, and recorded a place of the planet. His next observations were on August 12th, when he met with a star of the 8th magnitude, in the zone which he had gone over on July 30th, which did not then contain this star. Of course, this was the planet—the place of which was thus recorded a second time, in four days of observing. A comparison of the observations of July 30th and August 12th, would, according to the principle of search which he employed, have shown him the planet; but he did not make the comparison till after the detection of it at Berlin. The planet, however, was secured, and two positions of it recorded, *six weeks* earlier than in any other observatory, and in a sys-

tematic search expressly undertaken for that purpose, so that Mr. Challis, though not acknowledged as the first discoverer, has at least the satisfaction of having seen and recorded the position of this new-found planet six weeks earlier than he who is considered the real discoverer.

This planet appears like a star of the 8th magnitude, and consequently may be seen with a moderate degree of magnifying power; but it will be difficult to distinguish it from small neighbouring stars, unless with a very high power, when a disk may be perceived. Its distance from the sun is reckoned about 30 times that of the earth, or 2,850,000,000, that is, two thousand eight hundred and fifty millions of miles, or, more than a thousand millions of miles beyond the orbit of Uranus. The apparent disk of this planet subtends an angle of something more than 3 seconds, and its diameter will consequently be nearly 50,000 miles. Of course, it is about 250 times larger than the Earth, and three times larger than Uranus; and above a hundred times larger than the whole mass of the Earth and Moon, Venus, Mercury, Mars, Ceres, Pallas, Juno, and Vesta taken together. So that here we have a planet, which has been hid from the view of mortals in the profundity of space for thousands of years, exceeding in bulk a large retinue of spacious worlds: Jupiter and Saturn alone are its superiors. Its apparent motion when discovered was retrograde at 4 seconds per day. Its revolution round the sun is supposed to be accomplished in 190 years.

Mr. Lassell of Starfield, near Liverpool, stated that soon after its discovery, he had different views of it, and believes that he may confidently assert that, *it is surrounded by a Ring* like that of Saturn, placed three diameters from the body of the planet. This discovery appears to be confirmed by some late observations of Professor Challis. "I have been able," says he, "with the Northumberland telescope, to verify Mr. Lassell's suspicions of a *Ring*. I first received the impression of a ring on the 12th January, 1847. Two independent drawings made by myself, and my assistant Mr. Morgan, gave the same representations of its appearance and position. The ring is very little open. Its diameter makes an angle in the south preceding quadrant of 66 degrees with the parallel of declination. The ratio of the diameter of the ring to that of the planet is by estimation that of 3 to 2. I am at a loss to account for my not having noticed the ring earlier."

It also appears that Neptune is attended with at least one *satellite*, which Mr. Lassell has several times seen. In a

letter dated September 20, 1847, he informs the editor of the *Times*, that "he has ascertained the period of this satellite to be 5 days, 20 hours, 50 minutes, 45 seconds. The projected orbit is a narrow ellipse, with an axis inclined to about 28 degrees to the ecliptic, and with its semi-axis subtending about 18 seconds, so that the satellite is about 250,000 miles from the planet. This satellite is much brighter in the preceding than in the following half of its path. This variation seems to show that one side of the satellite has less light than the other." It is likewise evident that this satellite must be a body of very considerable size, otherwise, it could not be visible at such an immense distance. It is probably much larger than any of the satellites of Jupiter or Saturn, and may far exceed our globe in magnitude. The heliocentric longitude of this planet, on the 4th of August, 1846, was 326° 39′ and the north polar distance 102° 57′.

The discovery of this far distant planet, in the manner in which it was effected, constitutes not only a new era in the progress of celestial science, but also evinces the perspicacity of the human intellect, and the certainty and uniformity of those physical laws by which the bodies of the planetary system are directed, and that the law of gravitation is extensive in its influence, reaching far beyond what were formerly considered the boundaries of our system, and probably exerting its energies throughout all the worlds that roll through the spaces of infinitude. We have here *a new confirmation* of the theory of universal gravitation. The first step in the exhibition of that law was, the discovery made by Newton that the earth attracts the moon. The principle was also found to explain the revolution of the planets round the sun. Besides, it was found that the movements of the secondary planets round their primaries are owing to the same cause. The application of this law likewise explained certain anomalies in the motion of the moon and planets, which were otherwise difficult to account for. A great inequality in the movements of Jupiter and Saturn, which was long unaccounted for, was at length traced to their reciprocal action on one another by the operation of this law. The effects of the attraction of planets that could be observed, and whose names were known, were thereby calculated. In respect to the newly discovered body—the mean distance and position—the *mass*, and the form of its orbit, were all unknown. But, by its observed effects these were all so well determined as to guide the observer almost to the very point of the heavens where it was first seen. This fact stands almost alone in the records

of astronomical science. There has been no discovery of the same kind before it in the annals of astronomy, and it may lead to other discoveries of a similar kind. We have now no reason to conclude, that we have as yet descried the utmost boundaries of the solar system, since a body of so great magnitude has been ascertained to exist and to prosecute its annual course around the sun, at nearly double the distance of Uranus. If there be another planet or more beyond the orbit of Neptune, the observations of a number of years upon the movements of this body may lead to a like result again, and to bring to view other spacious orbs which have hitherto been concealed in those distant regions of space. It is in this way that the Creator crowns the exertions of human genius and the investigation of his works with success—by opening to our view a more expansive prospect of his boundless and eternal empire.

The Planet Hebe.—The brilliant discovery of the planet Neptune by Adams and Le Verrier has been closely followed by that of another, which has been detected by M. Hencke the discoverer of Astræa. On the 1st of July, 1847, at 10 h. 40 m. P. M., M. Hencke of Dresden discovered a second star, not previously marked in his map, of about the 9th degree of magnitude, in 257° 6′ right ascension, and 3° 42′ south declination. This new planet was observed on the 5th July from the Observatory of Berlin in the meridian, and in the refracting telescope. This body is considered as belonging to the smaller planets between Mars and Jupiter. This planet has been subsequently observed by M. Schumacher, M. Encke, M. Rumker, Mr. Hind, Professor Challis, Dr. Peterson and Mr. Lassell. Mr. Hind has computed its elements as follows :—

Epoch of mean anomaly, July, 1847, Greenwich mean time	283° 56′ 54″
Longitude of perihelion	8° 17′ 24″
Inclination	137° 25′ 35″
Eccentricity	.238910
Mean diurnal motion	886″
Sidereal period	4.004 years.

From these statements it appears that this planet comes between Vesta and M. Hencke's other planet Astræa. It has been named *Hebe*, following the nomination of the illustrious Gauss, to whom the office was delegated by Hencke.

The Planet Iris.—On the night of Friday the 13th of August, 1847—only about six weeks after the discovery of Hebe—Mr. Hind, the astronomer at Mr. Bishop's observatory,

Regent's Park, London, discovered an asteroid, which he believed was a new planet belonging to the group between Mars and Jupiter. Subsequent observations have confirmed the accuracy of that opinion, and placed beyond doubt this further triumph of English astronomers. Mr. Hind has since favoured the scientific world with the following particulars of this interesting wanderer, now for the first time recognised as belonging to our solar system.—"In addition to the Berlin maps," says Mr. Hind, "which we have revised, and in some instances corrected, elliptical charts of stars down to the 10th magnitude have been formed for some of the hours of Right Ascension, which it is Mr. Bishop's intention to publish as soon as they are completed. On the 13th of August, I compared Wolfe's map with the heavens, and was surprised to find an unmarked star of 8.9 magnitude in a position which was examined on June 22d and July 31st, without any note being made. The mere existence of a star in a position where before there was none visible, would not have been sufficient to satisfy me as to its nature, because during an eight-month's search, I have met with very many variable stars, a class which I believe to be far more numerous than is generally supposed. But, on employing the wire micrometer, we were enabled, in less than half an hour, to establish its motion, and thus to convince ourselves that I had been fortunate enough to discover a new member of the planetary system. It may appear to many rather bold to announce the existence of a new planet from the detection of so small an amount of motions as 2″.5 in right ascension; but such is the firm mounting of the large refracting telescope, and the perfection of the micrometers, (for which we have to thank Mr. Dollond,) that a far smaller change would have been sufficient to convince us of the nature of the object in question." The following are all the observations yet made:—

	h.	m.	sec.	Right Ascension of Iris.			South Declination.		
August 13,	9	39	46	19h.	57m.	30sec.	13°	27′	21″.5
	10	37	24	19	57	28	13	27	27.6
14	9	23	58	19	56	38	13	29	14.0
15	9	0	39	19	55	47	13	31	4.3

The name *Iris* was fixed upon by Mr. Bishop as an appropriate name for this new planet. The symbol adopted for its designation is a semicircle with an interior star. Mr. Hind says, "This planet has been detected in a systematic search instituted expressly with the view to the discovery of such a body, and commenced in November, 1846. The Berlin maps were employed as far as they extend; small

stars of the 9th or 10th magnitude, not marked in the maps, being inserted from time to time, as they came under examination." Observations of *Iris* have likewise been made by Professor Challis, Mr. Graham, Dr. Peterson at Altona, M. Rumker at Hamburg, and Professor Encke at Berlin.

THE PLANET FLORA.—Since the discovery of the planet *Iris*, Mr. Hind, at Mr. Bishop's observatory, South Villa, Regent's Park, has discovered another, within little more than two months after Iris was discovered. This new body was discovered on October 18, 1847. A few hours' observation proved it to be a new planet—the eighth of the remarkable group between the orbits of Mars and Jupiter. Since the epoch of discovery the brightness of the planet has considerably increased, and now equals that of a star of the eighth magnitude. At Mr. Bishop's request, Sir John Herschel has named it "*Flora*," with a flower (a rose) for the symbol. This new body has also been observed by Professor Challis, E. I. Cooper, Esq., Mr. Graham, Professor Encke, Professor Schumacher, M. Peterson and M. Rumker.

From the above statements it appears that three new primary planets have been brought to light during the year 1847, and that, too, within less than the space of four months, the first of them having been discovered on the 1st of July, and the third on the 18th of the following October. It is remarkable, too, that they all belong to that class of comparatively small bodies, sometimes called *Asteroids*, which move between the orbits of Mars and Jupiter, and are all invisible to the naked eye. Those bodies revolve nearly at the same distance from the sun, and the times of their revolutions round the sun are not much different from each other, and they are now found to be at least *eight* in number. There is a considerable degree of mystery that hangs over the facts and circumstances connected with these bodies, which prevents us from forming precise and definite conceptions respecting their nature and destination. It is generally supposed that they once formed the component parts of a large planet, which formerly revolved near the regions they now occupy, but, by some powerful internal force, had been disrupted into a number of smaller planets, which form the bodies which have been lately discovered. How many of these smaller bodies may exist it is now impossible to determine, since others may still be discovered; for it would be as unreasonable to conclude that we have now discovered the whole of them, as it would have been when only two or three of them were dis-

covered. Between the beginning of 1801, and 1807, four of these bodies had been detected, but no farther discovery was made in reference to them till December, 1845, when Astræa was discovered.

Various inquiries are suggested to the mind when contemplating the peculiar phenomena which these bodies present. If these small planets once formed the component parts of a large planet, at what period did the disruption take place? Was that planet then inhabited? And if inhabited, what was the fate of its inhabitants? Were they entirely destroyed by the awful catastrophe? or, did the inhabitants of the different fragments fly off along with that portion of the original planet which they occupied? Are these bodies still inhabited? or, are they flying like shattered masses, and barren deserts, through the voids of space? And if so, are they ever again to be repeopled? To such inquiries, however, no satisfactory answers can be expected while we remain in the present state. On the other hand, if we do not admit the hypothesis of a large planet having been disrupted, it is very difficult to account for the present position, motions, and other phenomena of these bodies, so very different from the harmony, proportion, and order, which characterize the other arrangements of the solar system. As already stated, they are nearly of the same distances from the sun, and perform their revolution nearly in the same periods; their orbits are more eccentric, and have a much greater degree of inclination than those of the other planets; and what is very singular and unaccountable, *their orbits cross each other*, so that there is a possibility of these planets impinging upon each other in the course of their revolutions. These circumstances seem to indicate that the bodies in question are not in that order and arrangement in which we should suppose an all-wise Creator would have placed them at their original creation, so that, whatever view we take of these anomalous bodies, there appears to us something inexplicable, mysterious and incomprehensible. But we may rest assured that their present state, whatever it may be, is in full accordance with the wisdom, rectitude, and benevolence of the *Moral Governor* of the Universe.

Rapid Progress of Astronomical Discovery.—Since the beginning of the 17th century, a little before the telescope was applied to the heavens, no less than thirty-one bodies, unknown before, have been added to our views of the Solar System. In the year 1608, seven bodies were known to

belong to our system, namely, the Sun and Moon, Mercury, Venus, Mars, Jupiter, and Saturn. In 1700, there had been added eleven moving bodies, namely, four satellites of Jupiter, five of Saturn, the Earth itself, which was now fully recognised as a planet, and Halley's comet, though the prediction had not been verified. In 1800, there had been added *nine*, namely, Uranus and its six satellites, with two satellites of Saturn. These were all discovered by the late Sir Wm. Herschel; and this celebrated observer, at his death, left the solar system half as large again, in number of bodies, as he found it. Since the beginning of the year 1800, there have been added twelve, namely, Vesta, Juno, Ceres, Pallas, Astræa, Hebe, Iris, Flora, Neptune, the satellite discovered by Mr. Lassell as revolving round the planet Neptune, Encke's comet, and Biela's comet.

Notwithstanding the discoveries which have lately been made in the planetary system, and in other regions of the heavens, we are not to imagine that we have yet arrived at boundaries in creation, beyond which we cannot pass. Only a few years have yet passed since the planet Saturn was considered as the utmost boundary of our planetary system, whose orbit is removed 900 millions of miles from the sun. But now, planets have been discovered at double and treble this distance, at eighteen hundred millions, and at three thousand millions of miles from this central luminary, and at such immense distances retained in their orbits, and guided by the influence of the attractive powers of the sun. The planet Neptune moves in an orbit five thousand seven hundred millions of miles in diameter, and about eighteen thousand millions of miles in circumference; and were a steam carriage to move round this vast circle at the rate of twenty miles an hour, it would require more than a hundred thousand years before it would complete the vast circuit. As we have no reason to conclude that we have not reached the utmost bounds of our system, it is not at all improbable that planets of a large size may exist far beyond the orbit of Neptune, which may yet be discovered by the persevering efforts of our astronomers, and some of which may never be visible to mortal eyes. It will now be more difficult than formerly to make delineations of the orbits of the planets, when they are intended to be represented in the relative proportions of their distances from the sun, unless the delineation be made on a very large scale, for otherwise the orbits of Mars, the Earth, Venus and Mercury, would appear so close to each other as scarcely to be distinguished.

On the whole, what further discoveries may yet be made in the celestial regions it is scarcely for us to anticipate. But in proportion to the number of those who devote themselves to celestial observations, and in proportion to the improvements that may be made on telescopes, and other instruments of observation, may we expect that still more brilliant discoveries will be unfolded to our view. It is to be hoped that American astronomers will, ere long, be instrumental in making new discoveries in the heavens, since some of them have lately procured most powerful instruments of observation. It is to be hoped that Professor Mitchell, of Cincinnati, who has been furnished with an observatory, and an excellent instrument of observation, will soon comply with the requisition of Struve, and measure all the double and multiple stars south of the equator. It is also confidently expected that Mr. Bond of Cambridge, Massachusetts, will follow up his discovery of analyzing the great nebula of Orion by similar discoveries in the nebulous regions of the heavens. The great Cambridge achromatic telescope is an instrument which does honour to the Harvard University, and to the United States. From what it has already performed, it appears scarcely inferior to the monster telescope of the Earl of Rosse, 54 feet in length, and 6 feet in diameter.

II.

BRIEF SKETCH OF THE HISTORY OF ASTRONOMY.

Astronomy was undoubtedly one of the earliest of the sciences cultivated by the human race. Some of its facts and first principles must have been known from the beginning of the world. For when the shades of night have opened to view the azure firmament, diversified with a multitude of shining orbs—the moon walking in brightness—the planets moving in their courses—and the host of stars displaying their diversified radiance—such a scene must have attracted the attention of every spectator, and led him to observe their apparent motions, and to inquire into their order and arrangement, and their use in measuring the exact length and proportions of days, and months, and years. Hence our English poet, Milton, very properly represents our first progenitors, Adam and Eve, celebrating the praises of their Maker, after taking a survey of the nocturnal heavens.

Adam. "These are thy glorious works, Parent of Good,
Almighty! thine this universal frame,
Thus wond'rous fair; thyself how wond'rous then!
Eve. Unspeakable! who sitt'st above these heavens
To us invisible, or dimly seen
In these thy lowest works; yet these declare
Thy goodness beyond thought, and power divine," etc.

Hence we find that Josephus, in his book of the "Antiquities of the Jews," relates that "Seth and his descendants were persons of happy tempers, and lived in peace, employing themselves in the study of astronomy, and in other researches after useful knowledge." He also remarks that, "God indulged the antediluvians with a long life, that they might bring astronomy and geometry to perfection." And the long lives of men, at that period, when many reached the age of eight or nine hundred years, had a tendency to improve the science of astronomy; since the same individual might observe the planet Saturn go through more than thirty revolutions. We have, therefore, reason to conclude that many of the antediluvians were intelligent astronomers: but their observations, if they were ever recorded, must have perished in the general deluge, unless Noah, who was a wise and good man, had secured some of the most valuable of them in the ark, and transmitted the results to his posterity.

After the deluge, the nations most noted for the cultivation of the science of the heavens were the Chaldeans, the Egyptians, and the Chinese. It is remarked by Josephus that Abraham was a most attentive observer of the stars; that he was a person of great sagacity, both for understanding all things, and persuading his hearers, and that he first brought astronomy from Chaldea into Egypt.

The Egyptians appear to have made some progress in astronomy, at as early a period as the Chaldeans. Their Pyramids, the most ancient monuments in the world, prove their skill in practical astronomy, as they are all situated in such a manner, that their several sides front very exactly the four cardinal points, east, west, north, and south. The system adopted by the Egyptians was the following: they conceived that the planets Mercury and Venus revolved like satellites, around the sun, their orbits being carried along with him in his revolution round the earth. They supposed the earth immovable as the centre of the system, and the other celestial bodies to turn around the same centre; first the moon, then the sun, about which they supposed Mercury and Venus to revolve, next the planet Mars, then Jupiter, next to Jupiter, Saturn, and lastly the sphere of the fixed stars. The Chinese pre-

tend that their nation studied astronomy soon after the flood, and date their astronomical knowledge from Fohi, the first of their kings; supposed by some to have been Noah, as it is understood that he journeyed with his children in the direction of China, about the time of the building of the tower of Babel.

Among the Greeks, astronomy was cultivated by Thales, the Milesian, Anaxagoras, Anaximander, Pythagoras, Aristarchus and others. Pythagoras, who flourished about five hundred years before the Christian era, taught that the sun was in the centre of the universe; that the earth is globular, and moves round the sun; that Venus is the morning, as well as the evening star; that the moon reflects the sun's rays, and is inhabited; that the stars are worlds, and that comets are wandering stars. This is nearly the system which was restored by Copernicus, in the fifteenth century.

Hipparchus, born at Nice, in Bithynia, appears to have made considerable advances in the cultivation of every branch of astronomy. He flourished about one hundred and forty years before Christ. He was among the first astronomers on record who attempted to number the stars, and to determine their exact positions. He was first induced to commence this labour in consequence of the appearance of a new star, in order that succeeding astronomers might learn whether any changes take place in the heavens.

Ptolemy, a native of Pelusium, in Egypt, born in the year 69, is the most ancient astronomer whose works have been handed down to our times. His Almagest, or the great composition, is that to which we are indebted, not only for his own observations, but for almost all that remains of Hipparchus, Aristillus, Timocharis, and the ancient Babylonians. According to the system of Ptolemy, the earth is immovable in the centre of the universe, and the planets move round it in the following order: first the moon, then Mercury and Venus; next to Venus the sun; then Mars, Jupiter, and Saturn, in the order here stated; and above all these, the firmament of the fixed stars, all which were conceived as revolving around the earth every twenty-four hours. He supposed that the planets moved round the earth, each in a vast solid transparent globe, having the planet attached to its surface; and as these transparent spheres did not account for all the motions and apparent irregularities of the heavenly bodies, he contrived other and still more complicated machinery, such as cycles, epicyles, deferents, etc., in order, if possible, to solve appearances. This system, notwithstanding its absurdity, and

its contrariety to the appearances of the universe, continued in vogue, even among the learned, for the space of more than one thousand four hundred years, or till the middle of the fifteenth century. During this period, a few individuals appeared who cultivated astronomy, such as Almansor, Almanon and others among the Arabians; Ulugh Beigh, a prince of Tartary; Alhazen, an Arab in Spain; Alphonso X., king of Castile; Roger Bacon, and several others; but they all adopted the absurd hypothesis of Ptolemy.

About the beginning of the sixteenth century, Copernicus, a bold and original genius, began to be distinguished for his attainments in astronomy. Perceiving that the clumsy and unnatural system of Ptolemy could never account for the motions and appearances of the celestial orbs, he adopted the Pythagorean system, which had been broached five hundred years before Christ, and wrote a profound treatise in confirmation of it, entitled, "Astronomy Restored; or, The revolutions of the Celestial Orbs." With a bold and daring hand, he dashed the crystalline orbs of Ptolemy into pieces, swept away his cycles, epicycles, and deferents, placed the sun in the centre of the system, removed the earth from its quiescent state, and set it in motion through the regions of the firmament, in company with the other planetary orbs. This system was at first violently opposed, both by the vulgar, the dignitaries of the Romish church, and pretended philosophers, as contrary both to sense, reason, and Scripture, and many of its abettors were subjected to violent persecutions. But it is now universally received by all men of learning, and by every one who has investigated the motions and other phenomena of the heavens. It has opened to our view the harmony and order of the planetary system, the wisdom and intelligence of its great Author, and laid the foundation of all the discoveries which have subsequently been made in this science. It was afterwards ably supported by the writings and observations of Galileo, Kepler, Gassendi, Hevelius, Huygens, Cassini, and other celebrated astronomers, by whom its principles have been established on a foundation stable and permanent as the laws of the universe.

About sixty or seventy years after the publication of this system, the invention of the telescope, and the discoveries made with this instrument by Galileo, tended to confirm its principles, and to expand our views of the sublimity, the variety, and multitude of the objects which the universe displays. This illustrious astronomer first discovered, by his telescope, the satellites of Jupiter, the phases of Venus, the

spots of the sun, and the rotation of this globe round its axis, the mountains and vales in the moon, the stars in the Milky Way, and an extraordinary phenomenon, which he imagined to be two small globes, connected with the planet Saturn. These discoveries were made about the year 1610, soon after the telescope was invented. About forty-eight years afterwards, Huygens, a celebrated mathematician and astronomer, in Holland, with telescopes of a much larger size than those of Galileo, discovered that the phenomenon connected with Saturn was, in reality, an immense ring surrounding that planet, and thirty thousand miles distant from every part of it. He, at the same time, discovered the fourth satellite of Saturn; and in these and other observations he used telescopes of his own construction of twelve, twenty-three, and even 120 feet in length. Some time afterwards, Cassini a French astronomer discovered the first, second, third, and fifth satellites of Saturn, and the periods of the rotation of Mars and Venus.

About the period to which we now allude flourished the illustrious Sir Isaac Newton, who laid the foundation of physical astronomy. About the year 1666, when in the twenty-fourth year of his age, he retired from Cambridge into the country on account of the plague, and sitting one day in an orchard, under a tree, an apple happening to fall upon his head, led him into a number of reflections. Reflecting on the power by which all terrestrial bodies gravitate towards the earth, it occurred to him, that as this power is not sensibly diminished in any distance to which we can recede from the earth's centre, there seemed reason to conclude that it extended much farther than it was generally supposed, and even might extend as far as the moon; and if this were true, he concluded that her motion would be influenced by it, and that probably it was this very force which retained her in her orbit. Following out these sublime conceptions, he began the composition of his immortal work, the "Principia," which was published in 1687, in Latin, under the title of "Mathematical Principles of Natural Philosophy." He also invented a reflecting telescope, which bears his name.

Contemporary with Newton were Dr. Hooke, Flamstead, Halley, Bradley, Roemer, Richer, Picard, Muraldi, and others, whose labours greatly contributed to the improvement of astronomy. Flamstead was the first astronomer royal in the Observatory at Greenwich, and, for nearly half a century, was assiduous in his observations of the heavenly bodies. He formed a catalogue of more than three thousand stars, with

their right ascensions, longitudes, solar distances, and apparent magnitudes. Roemer, a Danish astronomer, was the first who discovered the progressive motion of light. By comparing the eclipses of the first satellite of Jupiter with the times of their immersions and emersions given by the tables of Cassini, he found that the error of the tables depended on the distance between Jupiter and the earth, and hence he concluded that the motion of light was not instantaneous, and that it moved across the diameter of the earth's orbit in about sixteen minutes, or at the rate of 192,000 miles in a second.

Few discoveries were made in the heavens from the beginning of the eighteenth century till the period when Sir W. Herschel applied his large telescopes to the spaces of the firmament. His discoveries have greatly extended our views both of the planetary system, and of the sidereal heavens. On the 13th March, 1781, he discovered a new planet beyond the orbit of Saturn, to which he gave the name of Georgium Sidus; but it is now generally distinguished by the name of Uranus. On the 11th January, 1787, he discovered the second and fourth satellites which move round this planet; in 1790 and 1794, he discovered four other satellites revolving round the same body. In 1789, he discovered the sixth and seventh satellites of Saturn; he also determined the rotation and figure of this planet—discovered that it had a double ring, and was marked with several belts parallel to its equator. His son, Sir J. Herschel, has also distinguished himself by his unwearied observations on the heavens. In conjunction with Sir J. South, he produced a catalogue of 380 double stars, whose distances and angles of position they had determined with the utmost precision. Sir J. Herschel afterwards produced a list of upwards of 3300 double and triple stars, from his own solitary observations, accompanied with all the micrometrical measurements; and, about ten or twelve years ago, he went to the Cape of Good Hope for the purpose of making observations in the southern region of the heavens, and made some interesting discoveries. On the 1st of January, 1801, M. Piazzi, a Sicilian astronomer, discovered a small planet between the orbits of Mars and Jupiter, which has been named Ceres. On the 28th March, 1802, Dr. Olbers, of Bremen, discovered another planet, near the same region, which is named Pallas. On the 1st September, 1804, Mr. Harding, of Lilienthal, discovered another, which is named Juno, distinguished for the great eccentricity and inclination of its orbit. On the 26th March, 1807, Dr. Olbers discovered a fourth planet, which he named Vesta. The

latest discovery of this kind we have to record was made by Mr. Hencke, of Driessen, on the 8th December, 1845, when he discovered another planet somewhat similar to the four now mentioned, which is nearly at the same distance from the sun, and accomplishes its revolution in nearly the same period as the others. This planet has been named Astræa.

In the present day there are many distinguished cultivators of astronomical science, from whose observations and researches new discoveries may be expected. The names of South, Herschel, Airy, Smyth, Robinson, the Earl of Rosse, Schumacher, Struve, Harding, Bessel, Arago, and a multitude of others, are well known as distinguished cultivators of the science of the heavens. It is to be hoped that the Earl of Rosse, by means of the large and splendid telescope he has lately erected, will be enabled to make new discoveries, and to enlarge our views of the grandeur of the sidereal heavens. He has already analysed some of the nebulæ, and shown them to consist of immense clusters of stars which could not be perceived by any former telescopes; and this, we would hope, is only a prelude to still more sublime discoveries. What further advances astronomy may yet make, we dare not venture to anticipate. The number of individuals who devote themselves to this study is gradually increasing; its instruments of observation are rapidly improving; and we can scarcely set boundaries to the discoveries that may yet be made. In future ages, man, by the improvements in optical and other instruments, may be able to penetrate much farther into the distant regions of the universe than he has hitherto done, and may descry myriads of objects which have hitherto remained invisible in the unexplored regions of immensity. And after all the discoveries which mortals can bring to view from this terrestrial sphere, the greater part of the works of the Almighty will still remain to be explored throughout the ages of eternity.

III.

EXPLANATION OF ASTRONOMICAL TERMS.

Aberration, an apparent change of place in the fixed stars, which arises from the motion of the earth combined with the motion of light.

Achernar, a fixed star of the first magnitude, in the con-

stellation Eridanus, R. A. 1 hour, 31 minutes.—Dec. 58 degrees, 16½ minutes.

Achronical rising or setting of a planet, or star, is when it rises at sunset, or sets at sunrise.

Aldebaran, a fixed star of the first magnitude in the head of the constellation Taurus; sometimes called the *Bull's eye.*

Aerolites, or air-stones, are semi-metallic substances which are found to fall from the atmosphere in different countries. Some philosophers have imagined that they are the fragments of a planet that had been burst asunder.

Algol, a star in Medusa's head which varies from the second to the fourth magnitude.

Alioth, a fixed star in the tail of the Great Bear.

Almicanters, imaginary circles, which are supposed to be drawn parallel to the horizon, and to pass through every degree of the meridian, to show the altitude of a celestial object above the horizon.

Altitude, the height of the sun, moon, or stars above the horizon, reckoned in degrees and minutes, on a vertical circle.

Amphiscii, a name given to the inhabitants of the torrid zone, on account of their shadows falling at one time of the year towards the south, and at another time towards the north.

Amplitude, an arc of the horizon, contained between the east or west point of the heavens, and the centre of the sun or a star at the time of its rising or setting.

Anomaly, (the true,) the distance of a planet in signs, degrees, etc., from that point of its orbit which is farthest from the sun. The mean anomaly is, that which would take place if the planet moved uniformly in the circumference of a circle.

Antóeci, a name given to those inhabitants of the earth, who live under the same meridian, and at equal distances from the equator, but on opposite sides of it.

Antipodes, those inhabitants of the earth who live diametrically opposite to each other, or walk feet to feet, on opposite sides of the globe.

Aphelion, that point in the orbit of a planet in which it is at its greatest distance from the sun.

Apogee, that point in which the sun, or a planet, is farthest distant from the earth.

Apsides, the two most remote points of a planet's orbit, otherwise termed its aphelion and perihelion. A line joining those points is, the line of the apsides.

Armiliary sphere, an instrument composed of the principal circles which are drawn on an artificial globe.

Ascii, the inhabitants of the torrid zone; so called because the sun being twice a year in their zenith, their bodies at those times cast no shadow.

Axis of the earth, or of a planet; an imaginary line passing through the centre from one pole to another, round which they perform their diurnal rotation.

Azimuths, great circles which pass through the zenith and nadir, perpendicular to the horizon. The azimuth of a celestial body is an arc of the horizon contained between the east and west points, and a vertical circle passing through the centre of that object.

Belts, zones surrounding the body of Jupiter and Saturn.

Bissextile, (or Leap Year,) which happens every fourth year, contains 366 days; one day being added to the month of February.

Cardinal points of the compass; the east, west, north, and south points.

Cardinal points of the ecliptic; the first points of the signs, Aries, Cancer, Libra, and Capricorn.

Centrifugal force, that force by which any revolving body endeavours to fly off from the centre of motion in a tangent to the circle it describes.

Centripetal force, the tendency which a body has to the centre of its revolution.

Comets, erratic bodies belonging to our system, which move round the sun in very eccentric orbits, distinguished by their fiery tails and nebulous aspects.

Colures, two imaginary circles, or meridians, one of which passes through the solstitial points Cancer and Capricorn, and the other through the equinoctial points Aries and Libra.

Conjunction, is when two or more stars, or planets, are in the same part of the heavens.

Constellation, an assemblage of stars.

Cosmical rising or setting of a planet, or star, is when it rises with the sun in the morning, or sets with him in the evening.

Crystalline heavens, two solid orbs by means of which the ancients attempted to account for the apparent motions of the fixed stars.

Cusps, the points or horns of the moon, or of a planet.

Cycle of the moon, a revolution of nineteen years, in which time the conjunction and lunar aspects are nearly the same as they were nineteen years before.

Day, (astronomical,) the time between two successive transits of the sun's centre over the same meridian, which always begins and ends at noon.

Day, (sidereal,) the time which elapses during the rotation of the earth from one star till it returns to the same star again, and consists of 23 hours, 56 minutes, 4 seconds.

Declination is the distance of any celestial object north or south from the equator, reckoned in degrees, minutes, etc., upon a circle which is perpendicular to it.

Degree, the 360th part of a circle, or the 30th part of a sign.

Disk of the sun, or moon, is its round face, which, on account of the great distance of the object, appears flat.

Digit, the 12th part of the sun's diameter, which is used in the calculation of eclipses.

Diurnal motion of the earth, its rotation on its axis.

Eccentricity, the distance between the centre of a planet's orbit, and the focus round which it revolves.

Eclipse, a deprivation of the light of the sun, by the interposition of the moon; or of the light of the moon, by the interposition of the earth.

Ecliptic, a great circle in the heavens through which the sun apparently makes his annual revolution; but which is in reality the earth's path round the sun. It makes an angle with the equator of 23 degrees, 28 minutes.

Elongation, the annular distance of a planet from the sun, as it appears from the earth. It is applied only to the inferior planets, Mercury and Venus.

Emersion, the re-appearance of a celestial body after having been eclipsed.

Equation of time, the difference between real and apparent time, or between that shown by a true clock and a sun-dial. It depends on the obliquity of the ecliptic, combined with the unequal motion of the earth in its orbit.

Equator, or a great circle of the earth which separates the northern from the southern hemisphere. When referred to the heavens, it is called the *Equinoctial*.

Equinoxes, two opposite points in Aries and Libra, where the ecliptic cuts the equinoctial. When the sun is in these points the days and nights are equal to each other.

Foci of an ellipse, two points in the longest, or transverse axis, on each side of the centre; from each of which if any

two lines be drawn to meet each other in the circumference, their sum will be equal to the transverse axis.

Galaxy, or the Milky Way, a luminous and irregular zone which encompasses the heavens, which is found to be composed of an immense number of stars.

Geocentric place of a planet, is that position which it has when seen from the earth.

Gibbous, a term used in reference to the enlightened part of the moon, from the first quarter to the full, and from the full to the third quarter.

Gravity or *Gravitation*, that force by which all masses of matter tend towards each other.

Halo, a luminous circle round the body of the sun, or moon.

Heliacal rising of a star, is when it emerges from the sun's rays, and appears above the horizon before him in the morning.

Heliacal setting of a star, is when it is so hid in the sun's beams as not to be seen above the horizon after him in the evening.

Heliocentric place of a planet, is that in which it would appear to a spectator placed in the sun.

Hemisphere, the half of a globe or sphere.

Heteroscii, a name given to the inhabitants of the temperate zones, because their shadows at noon always fall one way.

Horizon, (the sensible,) a circle which separates the visible from the invisible hemisphere, and forms the boundary of our sight.

Horizon, (the rational,) a great circle which is parallel to the former, and whose poles are the zenith and the nadir.

Hour circles, the same as meridians—marking the hours.

Immersion, the moment when an eclipse begins, or when a planet enters into the shadow of the body that eclipses it.

Inclination, the angle which the orbit of one planet makes with that of another, or with the plane of the ecliptic.

Inferior planets, those that move at a less distance from the sun than the earth, which are Mercury and Venus.

Latitude of a place, its distance from the equator, reckoned in degrees and minutes upon the arc of a great circle.

Latitude of a star, or planet, is its distance from the ecliptic, reckoned in degrees, etc., on the arc of a great circle.

Lesser Circles of the sphere, those whose planes do not pass through the centre, and which divide the sphere into two unequal parts. *Great circles*, as the equator, meridians, etc., divide the sphere into two equal parts.

Libration of the moon, an apparent irregularity in her motion on her axis, by which we sometimes see more than the usual half of her disk.

Longitude of a place, its distance east or west from the first meridian, reckoned in degrees, etc., upon the equator.

Longitude of a star or planet, its distance from the first point of Aries, reckoned in degrees, etc., upon the ecliptic.

Lunation, the time between one new moon and another; which is, on an average, 29 days, 12 hours, 44 minutes, 3 seconds.

Maculæ, dark spots which appear on the face of the sun; and *Faculæ* are bright spots sometimes seen on the solar disk.

Magellanic clouds, certain whitish appearances in the heavens, in the southern hemisphere, supposed to consist either of an immense number of stars, or nebulæ.

Magnitudes, the stars are divided into six classes; the brightest are called stars of the first magnitude; the next in brightness, the second magnitude, etc.

Mean motion of a planet, that which would take place if it moved in a perfect circle, and equally every day.

Meridian, a great circle of the sphere which passes through the zenith and the poles, and perpendicular to the horizon.

Micrometer, an instrument fitted to a telescope to measure very small angles; as the diameters of the planets, etc.

Nadir, that point in the heavens directly opposite to the zenith, or immediately under our feet.

Nebulæ, luminous spots in the heavens, or clusters of small stars, discovered by the telescope.

Nocturnal arc, that space of the heavens which the sun apparently describes from the time of his setting to his rising.

Nodes, two points when the orbit of the moon, or of a planet, intersects the plane of the ecliptic.

Nucleus, a term used to denote the head of a comet.

Oblique ascension, an arc of the equinoctial contained between the first degree of Aries, and that point of it which rises with the centre of the sun or star.

Oblique sphere, that position of the globe in which either

of the poles is elevated above the horizon any number of degrees less than ninety.

Occultation is when a star, or planet, is hid from our sight by the interposition of the moon or some other planet.

Opposition, an aspect of the stars or planets when they are 180 degrees distant from each other, marked thus ☍.

Orbit, the curve which a planet describes in its revolution round the sun.

Parallax, the difference of the place of any celestial object, as seen from the surface of the earth, and from its centre.

Parallax of the earth's annual orbit, the angle at any planet subtended by the distance between the earth and the sun.

Parallels of latitude, small circles of the sphere which are drawn parallel to the equator.

Penumbra, a faint shadow observed between the perfect shadow and the full light in an eclipse.

Perigee, that point of the solar and lunar orbit which is nearest the earth.

Perihelion, that point of the orbit of a planet nearest the sun.

Periscii, the inhabitants of the frigid zones, because their shadows go round them for six months, or fall towards opposite points of the compass.

Phases, the different appearances of the illuminated parts of the moon, or planets.

Phenomenon, any extraordinary appearance in the heavens; as a comet, etc.

Planetarium, an astronomical machine for showing the motions and other phenomena of the planets.

Pleiades, or the seven stars, an assemblage of stars in the constellation of Taurus.

Polar circles, two small circles, 23 degrees and a half from the poles; the arctic in the north and the antarctic in the south.

Pole star, a star of the second magnitude in the tail of the Little Bear; so called, because it is near the north pole.

Precession of the equinoxes, a slow motion of the two points where the equator intersects the ecliptic, which go backwards about 50 seconds in a year.

Quadrant, the fourth part of a circle; or an instrument for measuring angles, and taking the altitudes of the sun and other heavenly bodies.

Quadrature, that position of the moon when distant 90 degrees from the sun; as in the first and third quarters.

Refraction, the bending of the rays of light in passing through the atmosphere, by which the heavenly bodies appear more elevated than they really are.

Retrograde, an apparent motion of the planets, in some parts of their orbits, when they seem to go backwards, or contrary to the order of the signs.

Right ascension is that degree of the equator which comes to the meridian with the sun, moon, or star, reckoning from the first point of Aries.

Rotation, the motion of any heavenly body round its axis.

Satellites, secondary planets or moons, which revolve round the primary planets.

Sextile, an aspect of the heavenly bodies, when they are 60 degrees distant from each other.

Sidereal, of or belonging to the stars.

Solstitial points, the first degree of Cancer and Capricorn at which the ecliptic touches the tropics.

Selenography, a representation of the moon, with a description of her different spots and appearances.

Sign, the twelfth part of the ecliptic, or 30 degrees.

Sphere, the concavity of the heavens in which the stars appear.

Superior planets, those which move at a further distance from the sun than the earth; as Mars, Jupiter, etc.

System, a number of bodies revolving round a common centre, as the planets round the sun.

Syzigy, a term usually applied to the moon, when in opposition, or in conjunction, or when at the new or full.

Telescope, an optical instrument for the purpose of viewing distant objects, particularly the sun, moon, planets, and stars. Telescopes produce their effects either by refraction through glasses, or reflection from speculums.

Telescopic stars, those stars which are only visible by means of telescopes. All stars beyond those of the sixth magnitude are reckoned telescopic stars.

Torrid zone, that part of the earth which is contained between the two tropics.

Trajectory, a term applied to the orbit of a comet.

Transit of a planet denotes its passing over another planet, or star, or across the disk of the sun.

Trine, an aspect of the planets when they are 120 degrees distant from each other

Tropics, two circles parallel to the equator, and 23 degrees 28 minutes distant on each side of it. They are named Cancer on the north, and Capricorn on the south.

Vector Radius, a line supposed to be drawn from any planet to the sun, which, moving with the planet, describes equal areas in equal times.

Vertical circles, the same as azimuth circles, or such as are drawn perpendicular to the horizon.

Prime vertical, is that azimuth circle which passes through the east and west points of the horizon.

Year, (the solar,) the time which the sun takes to pass from one tropic till it returns to the same again, and is 365 days, 5 hours, 48 minutes, 49 seconds.

Year, (sidereal,) the time which the sun takes to pass from any fixed star to the same again, and is 365 days, 6 hours, 9 minutes, 9 seconds.

Zenith, that point of the heavens immediately over head.

Zodiac, a zone surrounding the heavens, 18 degrees broad, in the middle of which is the ecliptic. The orbits of all the old planets are included in this zone.

Zodiacal light, a brightness sometimes observed in the heavens, somewhat similar to the Milky Way.

Zone, a division of the sphere between two parallels of latitude. There are five zones; one torrid, two temperate, and two frigid.

IV.

THE TELESCOPE.

As those who have acquired a taste for celestial observations, may wish to know something respecting the telescope, we subjoin the following very brief description.

There are two kinds of telescopes generally distinguished, —the refracting and the reflecting telescope, the former composed of lenses, or convex glasses, and the latter of speculums or mirrors combined with lenses. A common refracting telescope, for viewing some of the celestial bodies, may be con-

structed as follows:—Procure a convex glass, whose focal distance is about three feet. This may be known by holding the glass in the sun's rays, and measuring the distance between the glass and the place where the solar rays are condensed into a small spot. Place this lens at the end of a tube about three feet two inches long, in which there is a small sliding tube for fixing the eye-glass, and adjusting the focus for distinct vision. At the distance of three feet one inch, place a convex glass one inch focal distance. The object glass will form a picture, in its focus, of all the objects which are directly opposite to it, and this picture will be seen magnified in looking through the eye-glass. The magnifying power, in this case, will be in the proportion of three feet, or thirty-six inches to one inch; that is, the instrument will magnify the diameters of all objects thirty-six times, or make them appear thirty-six times nearer than when viewed by the naked eye; but as the image formed by the object-glass is in an inverted position, all terrestrial objects will appear through it as turned upside down. The opening at the object-glass, which lets in the light, should not exceed an inch in diameter.

With such a telescope, which may be constructed for five or six shillings, if the tubes be made of paper or pasteboard, the satellites of Jupiter, the crescent of Venus, the solar spots, and the inequalities on the surface of the moon may be distinguished. Galileo's telescope, with which he made the first discoveries in the heavens, did not magnify more than such a telescope.

THE END.

THE

ATMOSPHERE

AND

ATMOSPHERICAL PHENOMENA.

BY THOMAS DICK, LL.D.

AUTHOR OF "THE CHRISTIAN PHILOSOPHER," "CELESTIAL SCENERY," "PRACTICAL ASTRONOMER," ETC.

PHILADELPHIA:
E. C. & J. BIDDLE, 6 SOUTH FIFTH ST.
STEREOTYPED BY L. JOHNSON AND CO.
1848.

Printed by T. K. & P. G. Collins.

CONTENTS.

PART I.

THE NATURE, PROPERTIES, AND BENEFICIAL EFFECTS OF THE ATMOSPHERE IN THE SYSTEM OF NATURE, AND THE EVIDENCES WHICH ITS CONSTITUTION AFFORDS OF THE WISDOM AND BENEFICENCE OF THE CREATOR.

INTRODUCTION.

The works of God deserve our serious contemplation—His wisdom displayed in the various scenes connected with sublunary nature—His power displayed in the luminaries of heaven—His perfections manifested even in the invisible regions of nature—Atmosphere an important appendage to our globe—Outline of subjects in reference to the atmosphere..... Page 7

CHAPTER I.

Proofs that air is a material substance—Various experiments illustrative of this position—It produces sound, and shows a resistance to bodies passing through it—It excludes all other bodies from the place it occupies—A common bellows shows the materiality of air—Its waves frequently become an object of sight..... 11

CHAPTER II.

The weight and pressure of the atmosphere, and the quantity of matter it contains—Comparative weight of air and water—Experiments illustrative of its pressure—Barometer, and the mode of its action—Pascal's celebrated experiment with water and wine, to prove the pressure of the atmosphere—Remarks and reflections in reference to such experiments—Atmospheric pressure on the body of a man—This pressure varies—Weight of the whole atmosphere—Air decreases in density as we ascend to the higher regions—Scenes beheld from balloons—The pressure of the atmosphere illustrated by a great variety of simple experiments..... 13

CHAPTER III.

Facts illustrated by the pressure of the atmosphere—It explains suction—The process of a child sucking the breast—Why two smooth surfaces adhere with great force—Action of a boy's sucker—Adherence of shellfish to the rocks on which they are found—Why frosts

occasion a scantiness of water—Why a cask will not run, unless open at top—Mode of taking a draught of water, and the principle on which it depends—Action of the syphon—Remarks and reflections in reference to the atmospheric pressure—Its discovery struck the learned throughout Europe with surprise—Amazing pressure on the human body—How our dwellings are prevented from being crushed to atoms—Wisdom and benevolence of the Divine Being in such operations..... Page 23

CHAPTER IV.

The elasticity of the air, and the phenomena it explains—Important purposes effected by the atmosphere—Various illustrations of the elasticity of air—Effects produced in various substances by this property—Spring of the air equal to its weight—Is susceptible of dilatation and compression—Elasticity of air not capable of being destroyed—This property explains a great variety of appearances in nature and art..... 30

CHAPTER V.

The height of the atmosphere, or the elevation to which it extends beyond the surface of the earth—Height of the atmosphere, were it of uniform density—Its height, as ascertained from the twilight—Mode of finding its height from the effects of refraction—Probably extends to a much higher elevation than is generally supposed—Height of fire-balls, and other meteors—Universal space may be filled with ethereal fluids..... 35

CHAPTER VI.

The composition of the atmosphere—Atmosphere a compound fluid—History of this discovery—Component parts of which it consists—Properties of oxygen gas—Properties of nitrous oxyde—Its extraordinary effect on the animal spirits, illustrated in a variety of instances—Its singular effects on a student in Yale College—Its effects on the author, and other individuals—On insects, etc.—Reflections on this subject—Properties of nitrogen gas—Carbonic-acid gas—Where found—Its specific gravity—Fatal to all animals that breathe it—*Grotto del Cani*—Hints and cautions in reference to avoiding the pernicious effects of this gas—Atmosphere of our globe not to be considered the same as those of other planets—Adapted only to mortal men—May be improved, and rendered more salubrious, by the universal cultivation of the soil—Millennial era—Man has it in his power to effectuate important changes, were his moral dispositions renovated—State of the atmosphere before the deluge—Atmospheres of other planets—Reflections..... 39

CHAPTER VII.

The beneficial effects of the atmosphere in the system of nature—Air is essential to the growth of plants—Pressure of the atmosphere preserves water in its liquid state—Supports fire and flame—Respiration of all animals depends upon it—Various interesting experiments in relation to respiration—Reflections—Respiration in fishes—

Atmosphere essential to the process of evaporation—Density of the atmosphere gives buoyancy to the clouds—Is the source of winds, which are of essential use in the system of nature—Air is the vehicle of smell, the medium of sounds; and produces all the harmonies of music—The cause of that splendour and universal light around us, and of the morning and evening twilight—Disastrous effects which would follow were the atmosphere swept away—Divine wisdom and beneficence displayed in the arrangements of the atmosphere—Its transparency—Not capable of being frozen—Man has acquired a certain degree of sovereignty over it—Moral reflection in reference to this subject..... Page 49

CHAPTER VIII.

The wisdom and benevolence of the Creator, as displayed in the constitution of the atmosphere—Wisdom and goodness are manifest in the proportion which subsists between the different gases—In determining the relative specific gravity of these gases—And in the process for supplying the waste of oxygen, and promoting the renovation of the atmosphere—Concluding reflections—Folly of denying the reality of a future and invisible state of existence—Many of the objects of religion lie beyond the range of our coporeal vision, but are not, on that account, to be considered unreal—What ought to be our great object in our study of the sciences, and the investigation of the phenomena of nature?..... 68

PART II.

ATMOSPHERIC PHENOMENA.

CHAPTER I.

Aqueous Meteors.—1. Evaporation—Bishop Watson's experiments on this subject—Various facts in relation to this process—Quantity of water annually evaporated from our globe—2. Clouds, their height, size, etc.—Classes into which they have been arranged, Cirrus, Stratus, Cirro-cumulus, Nimbus, etc.—Electrical clouds, and the ravages they sometimes produce—3. Rain, imperfect knowledge of its cause—Quantity which falls in different seasons, and in different regions—Prognostics of rain—Uses of rain—4. Snow, how formed—Its flakes assume regular figures—Representation of some of these figures—Avalanches, and the ravages they produce—Uses of snow—5. Hail—Storms of hail in different countries, and the effects they produce—Hail-rods for preventing the formation of hail-showers—6. Dew, its formation—Hoar-frost—Fogs..... 75

CHAPTER II.

Winds.—1. Winds in general explained—2. General or permanent winds—Trade-winds—3. Periodical winds, or monsoons—4. Land and sea breezes—5. Variable winds—Destruction occasioned by stormy winds—6. Noxious and poisonous winds—The Harmattan—Sirocco—Samiel—The Simoom—Hurricanes—Tornadoes—Reflections in reference to noxious winds—Velocity of winds—Uses of winds..... 88

CHAPTER III.

Luminous and fiery meteors.—1. The *Aurora borealis*, its general appearances—Description of several striking auroras—Their appearance in the polar regions—Their supposed cause—2. *Luminous arches*, their phenomena and elevation—3. *Fire-balls*, description of their phenomena, size, motion, etc.—4. *Shooting, or falling-stars*—November meteors—Their striking appearance in the United States, in 1833—Their supposed origin—5. *Parhelia*, or mock-suns—Their general appearance—Description of one seen at Rome, illustrated with a figure—6. *Thunder and Lightning*—Description of a thunder-storm, with its accompaniments—How to estimate the distance of a thunder-cloud—Different kinds of lightning—Identity of lightning and electricity—Thunder-guard—Maxims to be observed during a thunder-storm—Concluding reflections..... Page 97

THE ATMOSPHERE

AND

ATMOSPHERICAL PHENOMENA.

PART I.

THE NATURE, PROPERTIES, AND BENEFICIAL EFFECTS OF THE ATMOSPHERE IN THE SYSTEM OF NATURE, AND THE EVIDENCES WHICH ITS CONSTITUTION AFFORDS OF THE WISDOM AND BENEFICENCE OF THE CREATOR.

INTRODUCTION.

All the works of God, throughout the immensity of the universe, display the character, perfections, and agency of the Supreme Creator, to every rational and Christian mind that surveys them with attention and intelligence. From the magnificent luminaries of heaven to the comparatively small globe on which we dwell, and the smallest microscopic animalcule that glides through its waters, we perceive the impress of omnipotence and skill, which infinitely surpass all the puny labours and inventions of man. These works were evidently intended by their Divine Author to be investigated, contemplated, and admired by all his intelligent offspring, that their conceptions of the Divine character may be expanded, and that they may be led to give unto Him "the glory due unto his name." The enlightened Christian, therefore, ought to devote a portion of his time and attention to the study and contemplation of the works of God, not only as a rational amusement, but as a solemn duty; for, in numerous passages in the sacred records, this duty is expressly inculcated: "Lift up your eyes on high, and behold who hath created these things"—"Stand still, and consider the wondrous works of God"—"The works of the Lord are great, sought out of all them that have pleasure therein"—"Great and marvellous are thy works, Lord God Almighty."

When we look around on the surface of the earth, and behold the beautiful and sublime landscapes which diversify its aspect, the variety of colours with which it is adorned, the myriads of trees, shrubs, and flowers which spring from its surface, and the rich perfumes they shed around them—the numerous animated beings which traverse the air, the ocean, and the earth, and the ample provision which is made for their subsistence and comfort—we can scarcely fail of being impressed with the conviction, that the Creator is a being of unbounded beneficence, that "His tender mercies are over all his works," and that the happiness of his sensitive and intelligent offspring is one great end of all his arrangements. When we consider the curious and exquisite structure of all the vegetable tribes, the numerous vessels with which they are furnished, the thousands of delicate tubes, invisible to the naked eye, through which their sap and juices are continually flowing to the leaves and branches, the millions of pores through which they shed their delicious odours, and the curious contexture and the numerous beauties which the microscope alone can discover in their leaves, prickles, stamens, petals, and flowers:—when we consider the numerous orders of animated beings—the wonderful diversity of structure they exhibit, in their eyes, ears, feet, joints, claws, wings, and movements—their numberless contrivances which enter into their construction and functions—the thousands of adjustments, adaptations, borings, claspings, and polishings, which enter into the body of an animal a thousand times less than a mite—the adaptation of all these contrivances to the purposes of life, motion, and enjoyment, and their correspondence to the surrounding elements in which such creatures pass their existence:—and, in particular, when we contemplate the structure and functions of our own corporeal frames; the hundreds of bones of different shapes and sizes which support it; the hundreds of muscles of different conformation, which give motion to its different parts; the thousands of glands, secreting humours of various kinds from the blood; the thousands of lacteal and lymphatic tubes, absorbing and conveying nutriment to the circulating fluid; the millions of pores, through which the perspiration is continually flowing; the infinite ramification of nerves, diffusing sensation throughout all the parts of this exquisite machine; and the numerous veins and arteries which convey the whole mass of blood through every part of the body ten times every hour:—when we consider these adaptations and arrangements throughout the vegetable and the animal kingdoms, we perceive the marks of a

Divine intelligence and skill, which completely throw into the shade the most exquisite contrivances of human genius, and which convince us that the *wisdom* of the Creator is *infinite*, and "his ways past finding out."

In short, when we lift our eyes beyond the boundaries of the globe on which we dwell, and look upwards to that boundless firmament where suns unnumbered shine, and planets and comets run their ample rounds—when we behold ten thousand times ten thousand of luminous and opaque globes of vast dimensions, scattered in magnificent profusion throughout every region of infinite space; when we contemplate the sun occupying a space which would hold one million three hundred thousand worlds such as ours; and when we contemplate globes fourteen hundred times larger than our world, flying through the voids of space with a velocity of thirty thousand miles an hour, and carrying along with them in their rapid career a retinue of surrounding worlds—we behold the effects of a Power which all the subordinate intelligences in the universe can never control, a power before which the mightiest achievements of human art sink into the same scale with the flutterings of a microscopic animalcule; a power which astonishes and confounds the imagination, which sets at defiance human calculations, but which conveys to the mind a most impressive idea of the grandeur of the Divine Being, and of the magnificence of that universe which his hands have formed!

It is not merely in the scenes of the visible world that the attributes of Deity are conspicuously displayed. Even in the invisible regions of creation, which are impalpable to the organs of human vision, the perfections of the Eternal Mind are no less apparent to the philosophic and Christian inquirer, than in those external scenes of beauty and magnificence which arrest the attention of every spectator. Could we descend to the central regions of our globe, and contemplate the processes which are going on in those unexplored and unexplorable recesses; could we penetrate into the depths of the ocean, and survey the multiplicity of objects which lie concealed in its unfathomable caverns; could we ascend on the wings of the wind with the vapours which rise from its surface, and contemplate all the regions and transformations through which they pass, till they again descend in refreshing rains on the mountains and vales; could we wing our flight beyond the denser regions of the atmosphere into those places where fire-balls and shooting-stars have their origin, and where the aurora borealis displays its fantastic coruscations; could we

ascend to the ethereal spaces which intervene between us and the celestial bodies, and investigate those apparently empty regions which surround the atmospheres of all the planets; or, could we penetrate into the chemical processes and changes which are incessantly going on among the invisible atoms of matter, in the union and disunion of the different gases, in the various modifications of crystallization, in the circulation of the sap and juices in the minutest flowers, and in the internal vessels of microscopic animalcules; we should doubtless behold the operations of a Wisdom and Intelligence no less admirable and astonishing than what is displayed in the visible scenes of nature which are obvious to every eye.

Of those invisible regions of nature now alluded to, the ATMOSPHERE is one in which we are particularly interested, and which exhibits a striking scene of Divine wisdom and beneficence.

The term atmosphere may be defined to be "that body of air, vapours, electric fluid, and other substances which surrounds the earth to a certain height." This mass of fluid matter gravitates towards the earth, presses upon its surface with a certain force, revolves with it in its diurnal rotation, and is carried along with it in its course round the sun, at the rate of sixty-eight thousand miles an hour. This fluid mass is invisible to the corporeal organs; and hence, the great body of mankind are apt to imagine that the regions around us, in which the birds fly, and the clouds move, are nothing else than empty space; and, were it not that they sometimes hear its sound in the breeze, and feel its effects in the whirlwind and the storm, they would be disposed to deny that such a thing as the atmosphere had an existence. There is, however, no appendage to our globe which is so essentially requisite to the comfort, and even to the very existence of animated beings; for, were the earth and the ocean, the springs and the rivers, to remain as they now are, but were the hand of Omnipotence to detach from our globe the atmosphere with which it is now environed, it is absolutely certain that, in a few minutes, and after a few sighs and groans, all the eight hundred millions of men that now people the earth, and all the other animated beings that traverse the air, the waters, and the land, would sink into the slumbers of death, and disappear for ever from the living world.

In elucidating this subject, the observations that will be made may be arranged under the following heads:—

I. To prove that air exists, and that it is a material substance.
II. To consider its weight or gravity, and the force with which it presses on all bodies on the surface of the earth.
III. To exhibit several facts which the pressure of the atmosphere tends to illustrate.
IV. To illustrate the elasticity of the air, and the effects it produces.
V. To offer some considerations for illustrating the height of the atmosphere, or its elevation above the surface of the earth.
VI. To illustrate its composition; or, the chemical principles of which common atmospherical air is composed.
VII. To illustrate its beneficial effects in the system of nature.
VIII. To exhibit the evidences which its constitution affords of the wisdom and benevolence of the Creator.

CHAPTER I.

AIR IS A MATERIAL SUBSTANCE.

THE first inquiry, then, is, What is that air, of the importance of which we hear so much asserted? We *see* nothing, it may be said—we *feel* nothing. We feel ourselves at liberty to move about without any let or hindrance. Whence, then, the assertion that we are surrounded by a substance called air? A few facts and illustrations only will be sufficient to elucidate this position.

1. If we take a rod, and make it pass rapidly through what appears empty space, we shall hear a sound and feel a slight resistance, as if something had intervened to prevent the motion of the rod.

2. If we take a large fan, or an umbrella, when fully stretched, and push it forcibly from us, we shall feel a very considerable resistance, and a person opposite will feel a certain impression made upon his face, as if some substance had come in contact with it. Were we to take a very large umbrella —say from twelve to fifteen feet diameter—and stand on the top of a high stair, or a building, twenty or thirty feet high, we might jump from such a position, while we held it fully

stretched, and gradually descend to the ground without violence or injury. It is on this principle that the instrument called a parachute is constructed, by means of which an aëronaut, while pursuing his aërial excursions, has left his balloon, when elevated nearly a mile above the surface of the earth, and descended in a few minutes to the ground, without shock or accident. Perhaps some contrivance of this kind might be useful to prevent accidents in the case of fires in large towns—when persons have attempted to jump from the windows of a third story to preserve themselves from being involved and destroyed in the burning mass. The circumstances now stated prove, that there is a certain material substance, though invisible, around us, which offers a sensible resistance to any body having a large surface when it is pushed rapidly through it.

3. That air is a material substance, appears from its excluding all other bodies from the place it occupies. Thus, if we take a glass jar, and plunge it with its mouth downwards into a vessel of water, only a very small quantity of water will get into the jar, because the air, of which the jar is full, keeps the water out; otherwise, if it were empty of every material substance, the water would rush in and completely fill the jar. Hence, we may learn why a vessel cannot be filled with water by plunging its orifice downward, and why a funnel, if its pipe fit closely to the neck of a bottle, is not convenient for pouring off liquors; for, in order to put water or wine into a bottle, the air must pass between the neck of the bottle and the funnel, to let the air out as the water rushes in. And hence, the practice in such cases, suggested by necessity, of pulling up the funnel a little when the liquor stops, in order to let the air rush out between the pipe and the neck of the bottle. It is on the principle now stated, that the diving bell is constructed, by which a person may descend to a considerable depth into the sea, and yet not be immersed in water, nor deprived of air for breathing.

4. If we take a smooth cylindrical tube shut at one end, and fit a plug or cork exactly to its open end, so as to slide along it, if the plug be so tight and soaked with grease, as to prevent all passage of any fluid by its sides, we shall find that no force whatever can push it to the bottom of the tube. There is, therefore, something within the tube, though invisible, which prevents the entry of the plug, and, therefore, possessing the characteristic of matter, and this something is air.

5. Let us take a pair of common bellows, and, after having

opened them, if we shut up the nozzle and valve-hole, and try to bring the boards together, we shall find it impossible. There is something included that prevents this, in the same manner as if the bellows were filled with flax or wool; but, on opening the nozzle, we can easily shut them by expelling this something that is within, which will issue with considerable force, and impel any thing that lies in its way. This something can be nothing else than the air of the atmosphere.

6. The air, though for the most part invisible, may, in certain cases, be rendered an object of sight. If we take a telescope of high magnifying power, and, in the forenoon of a hot summer day, when the sun is shining, look through it to distant objects, we shall perceive the air undulating about the objects somewhat like the waves of the sea, and rendering them undefined and obscure. This is the principal reason why very high magnifying powers cannot be used, with effect, on telescopes for land objects, in the day-time, when the sun produces undulations in the atmosphere; and the same cause frequently prevents distinct vision of celestial objects.

The above are clear proofs that the air, though not generally an object of sight, is, in reality, a material substance, as much so as water, wood, stones, or iron. This substance, in a state of rest, we call air; in a state of motion, we call it wind; and, in this state, its force is sometimes so great as to drive our wind-mills, impel our ships across the ocean, and even to overturn buildings, to tear up from their roots the largest trees, and to dash whole fleets to pieces of wreck.

CHAPTER II.

THE WEIGHT AND PRESSURE OF THE ATMOSPHERE, AND THE QUANTITY OF MATTER IT CONTAINS.

As air is demonstrated to be a body, like all other material substances, it must have weight, and the proportion its weight bears to other known substances is determined by experiment. If a bottle which contains about a quart be emptied of its air by means of an air-pump, or in any other way, and then accurately weighed in a nice balance, it will be found to be about sixteen grains lighter than it was before it was emptied

of its air, which shows that a quart of air weighs sixteen grains. A quart of water weighs about 14,620 grains, or nearly two pounds. If this last number be divided by sixteen, the quotient will be nine hundred and thirteen, which shows that air is nine hundred and thirteen times lighter than water; or, in other words, that it would require above nine hundred quart-bottles of air to weigh one quart-bottle of water. Other experiments which have been made to determine this point, lead to the result that for every cubic foot of air, five hundred and twenty-three grains, or, one and one-fifth ounce avoirdupois, are to be allowed; and, since a cubic foot of water weighs 1,000 ounces, the one divided by the other gives a result of eight hundred and thirty-three, the number of times that water is heavier than air. It is impossible to arrive at very great nicety in such estimates; but the general results of all the experiments which have been made on this point, lead to the conclusion that air is somewhere between eight hundred and nine hundred times lighter than water. These results, however, must be understood solely to apply to the air near the surface of the earth; for, as we ascend into the higher regions of the atmosphere, the air becomes gradually thinner and lighter, being less pressed with the air that is above.

We may now attend to the pressure which the atmosphere exerts upon the surface of the earth, and upon all bodies connected with it.

It has been proved by a variety of accurate experiments, that the atmosphere presses on every part of the earth's surface with a force, at an average, equal to about fifteen pounds on every square inch. This has been ascertained by what is called the Torricellian experiment. Take a glass tube about three feet long, open at one end, and hermetically sealed at the other: fill it with quicksilver, putting the finger upon the open end, turn that end downwards, and immerse it in a small vessel of quicksilver, without admitting any air, then take away the finger, and the quicksilver will remain suspended in the tube about twenty-nine and a half inches above its surface in the vessel, sometimes more and sometimes less, according to the state of the atmosphere. It is evident, then, that the quicksilver is kept up in the tube to this elevation by the pressure of the atmosphere upon the surface of the mercury in the basin; for, if the basin and tube are put under a glass, and the air extracted, all the quicksilver in the tube will fall down into the basin; and, if the air be re-admitted, it will rise to the same height as before; or, if an opening be made in the top of the tube and the air admitted, the quicksilver

will sink into the basin. The pressure, therefore, by the atmosphere on the earth, is the same as if a coating of quicksilver twenty-nine and a half inches thick were spread over every part of the earth's surface.

Now, it is proved that a square column of quicksilver twenty-nine and a half inches in height, and one inch thick, weighs just fifteen pounds, which counterpoise a column of air of the same thickness, extending to the top of the atmosphere; and, consequently, that air presses with this force upon every square inch of the earth's surface; and, of course, 2160 pounds on every square foot, and 19,440 on every square yard. The experiment now described is, in fact, nothing else than the common barometer. The tube of the barometer is filled with quicksilver, or mercury; it then stands in a basin of quicksilver, is connected with a ball containing quicksilver, on the surface of which the atmosphere presses, and, in most cases, stands at an elevation of about twenty-nine and a half inches, but subject to certain variations, according to the state of the atmosphere. When the weather is steady and serene, it rises to above thirty inches; when it is stormy and rainy, it frequently sinks to twenty-eight inches, or under, thus indicating the changes that take place in the weight of the air; and hence it has obtained the name of the weather-glass.

Were the same experiment made with water, instead of mercury, a tube must be provided of about thirty-six feet long; and then it would be found, that the water in the tube would be supported by the atmospheric pressure to the height of thirty-two or thirty-three feet. This costly experiment, which has been seldom repeated, was first performed by the celebrated Pascal, at Rouen, in Normandy, in 1647. He exhibited the experiment both with water and with wine, in order to show the different heights to which these fluids would rise, according to their respective densities. He procured, at a glass-house, tubes of crystal glass forty feet long, which were fixed to the mast of a ship, that was contrived to be raised or depressed, as occasion required. He appointed a day for performing this experiment, and invited all the philosophers and others who doubted of the pressure of the atmosphere to attend, and to be witnesses of the wonderful nature of his experiment. The result was, according to the calculations he had previously made, that the altitude of water in the tube was thirty-one and one-ninth Paris feet, equal to thirty-two feet two and a half inches English; and the altitude of the wine was somewhat greater, namely, thirty-one and two-thirds Paris feet, or thirty-two feet ten inches English; the wine,

on account of its superior levity, rising about seven and a half inches higher than the water. He performed this experiment to convince the Aristotelian philosophers of those times of the folly of a notion which then prevailed, that the rise of the mercury in the Torricellian experiment and the rise of water in pumps were produced, not by the pressure of the atmosphere, but by an occult quality, which they denominated "Nature's abhorrence of a vacuum." They asserted that, in the upper part of the tube, deserted by the quicksilver, there were contained some *spirits*, evaporated from the quicksilver; which, being rarefied, filled up that space, thus assisting Nature, in a great emergency, against her mortal enemy, a vacuum. "Well, then, gentlemen," says Pascal, "take your own way. Here are two tubes, the one I am to fill with water, and the other with wine. You will all readily admit that there is a greater quantity of spirits in wine than in water: and, consequently, that if the empty space between the upper surface of the fluids and the top of the tube be filled with spirits, there will be a greater quantity of spirits in the upper part of the tube containing the wine, than in the tube containing the water; and, of course, the wine will not rise so high as the water." To this they all readily assented. But, when the experiment was made, the wine was found to rise nearly eight inches higher than the water, as Pascal had previously calculated and predicted. This experiment was decisive; and, since that period, the figment of "Nature's abhorrence of a vacuum," along with many other absurdities, has been consigned to the slumber of the dark ages whence it originated.

A few years before the period now alluded to, the engineers of the Grand-duke of Florence, having received orders to raise a portion of water to the height of fifty or sixty feet, by means of a common pump, perceived, when they had made the attempt, that the pump refused its assistance when the water was to be raised above thirty-two feet. They communicated the circumstance to Galileo, an eminent philosopher of that age, and asked him the reason of it. Galileo was not a little surprised, and was unprovided with an answer. He, however, put a good face on the affair, and gravely replied, that "Nature abhorred a vacuum only to the height of thirty-two feet." Torricelli, the disciple of Galileo, vexed at the water's refusing to ascend more than thirty-two feet in a tube void of air, made a new experiment with quicksilver, in the manner already described. He saw the quicksilver in the tube fall down, and leave an empty space at top, and remain suspended

at the height of twenty-nine inches. "How," says he, "Nature abhors a vacuum only to the height of thirty-two feet when it is water that ascends in a tube void of air, and only to twenty-nine inches when it is mercury! Vacuum does not frighten her beyond these measures! But why does she fear it to far more than twenty-nine inches when it is water that rises? Very likely this horror at vacuity is an idle fancy, a mere philosophical cant, which we take for good coin without understanding it." Reasoning in this way, and repeating a variety of similar experiments, he was, at length, led to the conclusion "that the diversity of the elevation of the two different fluids proceeded from the diversity of their weight, and that they were supported and counterpoised by a column of air, of the same diameter, reaching the top of the atmosphere." Here the matter rests, and will rest throughout all succeeding generations.

This short sketch of the history of the experiments which relate to the pressure of the atmosphere will not be altogether out of place, if it has a tendency to guard us against the influence of preconceived notions, foolish prejudices, and of the authority of great names, which are some of the greatest obstructions to the expansion of the human mind, and the reception of useful knowledge. It was not before men began to emancipate themselves from such shackles that science commenced that brilliant career which has issued, in our times, in so many interesting and important discoveries. Similar prejudices are still prevalent in relation to the affairs of common life, the facts of science, and the important truths of religion. We are only yet beginning to cast off the yoke of that ignorance, under the guise of wisdom, under which the men of other times bowed with such abject submission. Religious prejudices, in particular derived from education and submission to mere authority, are frequently so strong that no species of reasoning, however convincing to an unbiased mind, is sufficient to subdue them. When certain dogmas or opinions, however futile, have got a firm hold on the mental faculties, all the arguments that can be derived from reason and philosophy, and even from the most cogent announcements of Divine revelation, are found altogether insufficient to displace them. And, as the fostering of erroneous opinions, in relation to religion, may endanger our best interests, both in relation to the life that now is and the life to come, it is of the utmost importance to all, and especially to young persons, that they examine, with care and without prejudice, every doctrine and opinion they embrace, without regard to

human authority; founding all their views and sentiments on the dictates of enlightened reason, and the plain declarations of the word of God.

From what has been now stated, we may easily compute the weight sustained by the body of a middle-sized man, in consequence of the pressure of the atmosphere. Suppose the average stature of the human body to be about five feet nine inches; suppose the breadth in front to be about one foot, and the breadth on each side half a foot; by allowing a little deduction for the narrowness of the head and feet, we may reckon about five feet in front, and five for the back part, and two and a half square feet for each side of the body, or fifteen square feet in all. It has already been stated that the atmospheric pressure on one square foot is **2160** pounds. Multiply this sum by fifteen, the number of square feet on the surface of the human body, and the product will be **32,400** pounds, or somewhat more than fourteen tons, or the weight of more than fourteen ordinary cart-loads of heavy goods. This is the pressure sustained by every middle-sized man—a pressure which would be insupportable, and even crush us to pieces, were it not that it is equal in every part; pressing with the same force upwards, downwards, and on every side; and is, at the same time, counterbalanced by the spring of the air within us, which is diffused through the whole body, and reacts with an equal force against the outward pressure. This pressure, however, is somewhat different at different times. When the air is lightest, the pressure is **31,150** pounds, and, when heaviest, about **33,660** pounds, making a difference of about **2500** pounds, the weight with which we are compressed more at one time than at another. This great difference in the atmospheric pressure is found greatly to affect the animal functions and the state of health. A person labouring under an asthmatical complaint will find his disorder increased when the air is light, as it has then less elasticity, and is not so capable of expanding the lungs. The air is generally the lightest in hazy and rainy weather, when the clouds descend, and the mists cover the mountain tops. Every one then feels the effect, by a certain degree of lassitude and depression of spirits, occasioned by the surrounding gloom, and by being deprived of an atmospheric pressure amounting to more than **2000** pounds. The fibres of the body are relaxed, the contractile force of the muscles diminished, and a languid circulation of the fluids ensues, which sometimes produce obstructions, fevers, and headaches; and, in most persons, a sort of indolence and gloomy inactivity. Whereas, when the air is

heavy, and the clouds ascend to the higher regions, and appear like fine fleeces on the blue vault of heaven, the nerves and fibres of the animal system are braced by the additional pressure of the atmosphere, the blood-vessels exert their full power, the solids are compressed, the fluids circulate with increased vigour, we feel light and alert, and the elevation of the animal spirits is increased by the splendour and activity of the surrounding scene.

Weight of the whole Atmosphere.—From the facts now stated, we may form an estimate of the weight of the whole body of the atmosphere which surrounds the surface of the earth. The surface of the globe contains, in round numbers, 200,000,000 of square miles; every square mile contains 27,878,400 square feet; and these two numbers multiplied together, produce 5,575,680,000,000,000; or, five thousand five hundred and seventy-five billions, six hundred and eighty thousand millions, equal to the number of square feet on the surface of the earth; which, multiplied by 2160 pounds, (equal to the pressure on every square foot,) produces the sum of 12,043,468,800,000,000,000; that is twelve trillions, forty-three thousand four hundred and sixty-eight billions, and eight hundred thousand millions; which is equal to the number of pounds which constitute the weight of the whole atmosphere, or 5,000,000,000,000,000; that is, about five thousand billions of tons. A more definite idea of this weight may be obtained by supposing a ball of lead, extending from London to Oxford, stretching sixty miles perpendicularly above us, and in every direction; or, in other words, a ball of lead one hundred and ninety miles in circumference, and about sixty miles in diameter. Suppose this ball placed on one end of an immense balance, and the whole atmosphere on the other, they would nearly counterpoise each other. So that this invisible fluid, which we are apt to consider as almost a nonentity, when considered as a whole, contains a weight which it is difficult for numbers to express.

It need only be observed further on this point, that the air decreases in density in proportion as we ascend to the higher regions of the atmosphere. At the height of seven miles, the air is four times rarer than at the surface of the earth; at the height of fourteen miles, it is sixteen times rarer; at the height of twenty-eight miles, it is two hundred and fifty-six times rarer; at the height of ninety-six miles, it is 268,435,456 times rarer; and at the height of five hundred miles, it has been computed, that a cubic inch of such air as we breathe at the surface of the earth, would be so much rarefied, that it

would fill a hollow sphere equal in diameter to the orbit of the planet Saturn, which is 1,800,000,000 of miles in diameter. This is a necessary consequence of the elasticity of the air, and of its want of compression in the higher regions; and that this is in reality the case, is proved by experiment as well as by calculation. When we take a barometer to the top of a mountain only half a mile in perpendicular elevation, the mercury falls from thirty to twenty-seven inches; and the fall of the mercury is in proportion the higher we ascend. Those travellers who have climbed to the tops of lofty mountains know, by experience, that the air is much thinner in those regions than in the plains below. Their breathing becomes difficult and painful, their hands and feet swell, and they are sometimes seized with a vomiting of blood. They also find, that the atmosphere becomes clearer as they ascend, and is unable to support the clouds. We are informed by Don Ulloa that, while he stood on the top of the Andes, in Peru, "the clouds, which were gathered below the mountain's brow, appeared like a tempestuous ocean, all dashing and foaming, while the lightnings were breaking through the waves, and the thunders rolling beneath his feet, far below the spot on which he stood. In the mean time he enjoyed a serene and cloudless sky, and left the war of the elements to the unphilosophical mortals on the plains below."

Those who have taken a flight to the higher regions of the atmosphere in balloons, have beheld scenes of a similar kind. Mr. Baldwin, who ascended in a balloon from Chester, in 1785, relates that at a certain elevation, the earth was entirely hid from his view by an immense mass of vapours, which he compares to a sea of cotton, tufted here and there by the action of the air, and, soon after, the whole became an extended pavement of white cloud. The reason of all this is obvious: the clouds are vapour, or water rarefied by heat. Vapour is lighter than air near the surface of the earth, and, consequently, ascends in it; but, in the higher regions, the air is thinner and lighter than these vapours, and, of course, is unable to support them beyond a limited height; which circumstance undeniably proves that the air is lighter the higher we ascend.

The pressure of the atmosphere may now be illustrated by a few simple experiments. The instrument called the air-pump affords, on the whole, the best means of illustrating the pressure of the atmosphere. This instrument bears a certain resemblance, in its principle and action, to the common house pump. It consists of a hollow cylinder or tube, in

which a piston is alternately raised and depressed by means of an iron rod attached to the handle of the pump. In the piston there is a valve, which opens by any pressure from below, and is shut by any superincumbent pressure, like the flapper of a pair of bellows. When the piston is forced down the valve is opened from below by the pressure of air, or whatever fluid the pump may contain. The fluid then gets above the valve, and is lifted up by the raising of the piston, and carried out of the pump, the valve being then shut by the pressure of the air above it. At the top, is a metal plate ground to a perfect plane surface, on which is placed an inverted glass jar or receiver, whence the air is to be extracted. A hole in the plate is connected with a tube which communicates with the pump-barrels. By working the handle of the instrument for some time, the receiver will soon be nearly exhausted of all the air it contains, and the effects produced in a vacuum, or place void of air, may then be exhibited. The following, among other experiments, may be shown by the air-pump. If the receiver be open at both ends, and the upper orifice be stopped by the hand, when the air is exhausted, the pressure of the external air will be such as to prevent the removal of the hand, and will cause a certain degree of pain. If a piece of bladder be tied tightly over the orifice, as the exhaustion proceeds, the bladder will be pressed inwards, and will finally burst with a loud noise. In the same manner, if a flat piece of window-glass be placed upon the orifice, when the air is exhausted, the glass will be broken into a number of pieces by the external pressure of the atmosphere.

But as comparatively few persons have an opportunity of performing experiments with the air-pump, a few simple experiments equally convincing, which every person has it in his power to perform, may here be described.

1. Take a wine or an ale-glass, and fill it with water; take a smooth piece of writing paper, and press it firmly against the edges of the glass, so that no air get in between the paper and the water, then turn the glass upside down, and the water will be supported by the pressure of the atmosphere upon the paper. That it is the external pressure of the atmosphere upon the paper which supports the water will appear, when we consider that the paper, instead of being convex, by the pressure of the water downwards, is concave, by the pressure of the air upwards. If a lighted candle be placed under the paper, with its flame touching the paper,

we may hold it for an indefinite length of time, without its producing any effect upon the paper, or setting fire to it.

2. Take a wine-glass, and burn a piece of paper in it, and while the paper is burning, if we place the palm of our hand firmly upon the edges of the glass, the glass will stick fast to the hand, producing a certain degree of pain, and it will require a considerable degree of force before the hand can be detached from the glass. In this experiment, the burning of the paper rarefies the air, nearly expels it from the glass, and then the atmosphere presses with its whole weight upon the hand.

3. Take a glass tube two or three feet long, of a narrow bore; plunge one end of it in a basin of water; apply the mouth to the other end, and draw out the air by suction; the water will instantly rise into the tube by the pressure of the atmosphere on the water in the basin; and, if we immediately place our thumb firmly on the upper part of the tube, and withdraw it from the water in the basin, the water will be suspended in the tube by the pressure of the atmosphere, although the tube is open below; but, when the thumb is removed from the upper part of the tube, the water in it will run out, in consequence of the pressure of the atmosphere from above.

Fig. 1.

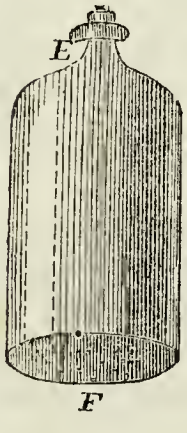
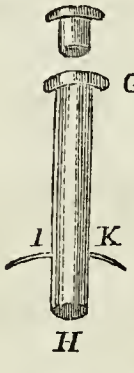


Fig. 2.



4. Take a tin vessel, six or eight inches long, and about three in diameter, with its mouth about a quarter of an inch wide, as E F, (fig. 1.) Pierce a number of small holes in its bottom, about the diameter of a common sewing-needle. Plunge this vessel in water, and, when full, cork it up, so that no air can enter at the top. While it remains corked, no water will run out, being prevented by the atmospheric pressure upon the bottom of the vessel; but the moment it is uncorked, the water will issue from the small holes by the pressure of the air from above. The same experiment may be made with a tin-plate tube, about an inch in diameter, open at the top, and having its bottom pierced with a small hole. When filled with water and tightly corked at the top, it may be carried for miles without losing a drop of water, notwithstanding the hole in the bottom.

5. In order to show the lateral pressure of the atmosphere, take a tube, as G H, (fig. 2,) six or seven inches long, having a small hole on each side, as I K. When filled with water,

and tightly corked, no water will run out from the sides of the tube, but the moment the cork is taken out, the water will run out at I and K, as represented in the figure.

6. Take a wine-glass and burn in it a piece of paper; then invert the glass, while the paper is burning, over a saucer full of water, the water will rush up into the wine-glass, in consequence of the air being rarified or driven out by the burning paper, and in consequence of the pressure of the atmosphere upon the surface of the water in the saucer.

These experiments show that the atmosphere presses in all directions, upwards, downwards, and laterally. This subject has been dwelt on somewhat particularly, because the atmospheric pressure forms an important element, and a mechanical power in the construction of steam-engines, atmospheric railways, and other modern inventions, which are now of such great utility in propelling carriages along railways, and steam-vessels across seas and oceans.

CHAPTER III.

FACTS ILLUSTRATED BY THE PRESSURE OF THE ATMOSPHERE.

Let us now attend to a few facts which the pressure of the air tends to explain and illustrate.

1. The atmospheric pressure explains the nature of the process vulgarly termed suction. When we attempt to take a draught of water out of a basin, or a running stream, it is commonly said that we draw in the water by suction; whereas the fact is, that instead of drawing the water into the stomach, we only draw the air into the lungs, and the atmosphere performs the other part of the operation. The process is simply this:—We immerse our lips into the water, so as to prevent the entrance of air into the mouth; we then make a vacuum in the mouth by drawing the air into the lungs, after which the pressure of the atmosphere upon the surface of the water forces it upwards into the mouth. That such is the process of receiving a draught of water when the mouth is held downwards, appears from this circumstance, that if the lips do not *touch* the water, we might draw in the air by what is called suction for twenty years, and not receive a single drop into the mouth.

The same principle explains the action of a child sucking

the breast of its nurse. The operation of cupping is performed in the same way. In this case, the operator takes a small glass, close at the top, and holding it for some time over the flame of a candle or lamp, the air is thereby rarefied, and part of it drawn out. The glass is then suddenly placed on the part of the body to be cupped, and adheres to the flesh by the external pressure of the air. The flesh rises in the glass, and the blood and serosities are forced from the wounded vessels into the glass by the atmospheric pressure on the parts around.

2. It is owing to the atmospheric pressure that two polished surfaces, which accurately fit each other, adhere with great force. This fact is well known to glass-grinders and polishers of marble. A large lens, when ground very smooth, requires more than the strength of a single individual to pull it directly from the tool. If the surface is only a square inch, it will require fifteen pounds to separate them perpendicularly, though a very moderate force will make them slip along each other. Were the surface six inches square, the force requisite to separate the two pieces would be equal to five hundred and forty pounds. But this cohesion is not observed, unless the surfaces are wetted or smeared with oil or grease, otherwise the air gets between them, and they separate without any trouble. That this cohesion is owing to the atmospheric pressure, is evident from the ease with which the plates may be separated in an exhausted receiver by means of the air-pump. The same cause contributes in a powerful degree to give effect to the cohesion of bodies by means of mortar and cements. When two pieces of wood are to be glued together, their surfaces are first made as smooth as possible; a glutinous substance is then applied to fill up all the pores and inequalities; they are then pressed together, which prevents the air from insinuating itself between them, and the external air then presses upon them with a force of fifteen pounds on every square inch. There can be no question that the stability of our houses and garden walls depends, at least in a great measure, upon the same principles; for the more completely every crevice between the bricks or stones is shut up, by means of mortars and cements, from the insinuation of the external air, the more firm and stable is the building.

To the same cause is to be attributed the action of a boy's sucker in lifting large stones from the ground. The sucker is made of stiff wetted leather fastened to a string; the moisture upon the leather, when it is pressed down upon the stone, prevents the air from getting in between the leather

and the stone, and if the sucker be four inches square, it will require a force of two hundred and forty pounds to separate it from the stone. In certain cases, such contrivances, on a large scale, might be sometimes useful as a mechanical power.

3. Another circumstance which is accounted for on this principle is, the strong adhesion of snails, periwinkles, limpets, and other molluscous animals, to the rocks on which they are found. The animal forms the rim of its shell so as to fit the shape of the rock on which it intends to cling. It then fills its shell either with its own body or with water. In this condition, it is evident, that we must act with a force equal to fifteen pounds on a square inch before we can detach it from the rock. This may be illustrated by filling a drinking-glass to the brim with water, and, having covered it with a piece of thin wet leather, place it upon a table, and it will be found to require a very considerable force to pull it straight upward. But, if we place a snail adhering to a stone in an exhausted receiver, it will drop off by its own weight. It is owing to the same cause that bivalve mollusca, such as *oysters* and *mussels*, keep their shells so firmly shut, and require such a degree of force to open them. But, if we grind off a bit of the convex shell, so as to make a small hole in it, the air gets in, and it opens with the greatest ease. The same thing takes place when it is put under the exhausted receiver of an air-pump. It has been lately discovered that it is owing to the same principle that flies and other animals have the power of walking on a perpendicular pane of glass, or on the ceiling of a room, with their backs downward. This has been proved to arise from a power they possess of squeezing out the air between the inside of their feet and the surface on which they tread, and thus being supported against the outside of their feet by the pressure of the atmosphere.

4. It is owing, in a great measure, to the pressure of the atmosphere, that frosts occasion a scantiness of water in our fountains and wells. This is not caused, as is generally supposed, by the freezing of the water in the bowels of the earth. The most intense frost of a Siberian winter would not freeze the ground two feet deep, but a moderate frost will consolidate the whole surface of a country, and make it impervious to the air, especially if the frost has been preceded by rain, which has soaked the surface. When this happens, the water which was filtering through the ground is all arrested, and kept suspended in its capillary tubes by the pressure of the air, in the same manner as water is suspended in a tube

which is closed at one end, as in the third experiment stated in the preceding chapter (p. 22). A thaw melts the superficial ice, and allows the water to run out in the same manner as it does when the thumb, in that experiment, is removed from the top of the tube.

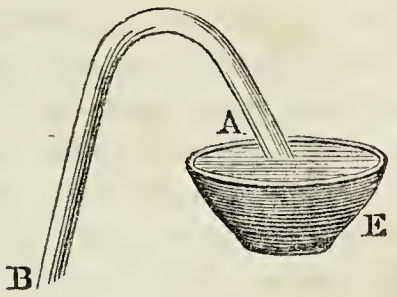
6. It is well known that a cask full of water, or spirits, will not run by the cock, unless a hole be opened in the top, or some other part of the cask. The reason is, that the air presses upon the opening in the cock, and prevents the liquor from flowing; whereas, when an opening is made at the top, the pressure of the air from above forces it down. If, indeed, the hole in the cask is of large dimensions, it will run without any other hole, because air will get in at the upper side of the hole, while the liquor runs out by the lower part of it. For the same reason, a small hole is made in the lid of a teapot to insure its pouring out the tea, otherwise, when the teapot is quite full, it would be difficult to make the tea run out at the spout, the pressure of the air from below tending to prevent it.

On the same principle depends the performance of an instrument used by spirit dealers, for taking out a sample of their spirits. It consists of a long tin-plate tube, A B, fig. 3, open at the top at A, and ending in a small hole at B. The end B is dipped into the spirits, which rise into the tube; then the thumb is clapped on the mouth A, and the whole is lifted out of the cask. The spirit remains in it till the thumb be taken off; it is then allowed to run into a glass for examination. We are informed by certain travellers, that some of the rude tribes of Asia and Africa, with whom they have travelled, have a similar method of acquiring a draught of water, though they do not understand the principle on which it depends. They provide themselves, in their journeys, with a long hollow cane, and, when they wish to drink, or to give their companions a draught of water from a stream or pool, they place the hollow cane in the water, and apply their mouth to the upper end, and draw out the air, when the water rushes in and fills the interior of the cane; they then apply their thumb to the upper end, take the cane out of the water, and apply it to the lips of their thirsty companion, when the water rushes into his mouth. This mode of taking a draught of water may, in some cases, be very convenient when we cannot easily apply our lips to the surface of a running stream.

Fig. 3.

The action of the syphon depends on the same principle. A syphon is a bent tube, the one end of which is longer than the other, as A B, fig. 4. If the tube be filled with water, and the shorter leg be placed in a vessel of water, E, immediately upon withdrawing the finger from the longer leg, the water will flow out till the liquid in the vessel is emptied.

Fig. 4.



By means of this instrument, we can convey water from a cistern over a rising ground, provided its perpendicular elevation above the level of the fountain does not exceed thirty-two feet, and that the leg, from which the water runs off, is *below* the level of the cistern; because the weight of a column of water, about thirty-two or thirty-three feet high, is equal to the weight of a column of air reaching from the surface of the earth to the top of the atmosphere. The pressure of the atmosphere upon the water of the vessel, or cistern, produces this effect.

It might be shown, that the common pump for raising water, the fire-engine, the steam-engine, the forcing-pump, and many other pneumatic and hydraulic engines, derive their power and utility chiefly from that extensive and universal agent—the pressure of the atmosphere; without the assistance of which many of our most powerful engines would be arrested in their operations, and sink into feebleness and insignificancy. But this chapter shall be concluded by a few general remarks, suggested by this subject.

The discovery of the pressure of the atmosphere, and of its agency in the system of nature, formed a new era in the history of science. However common it is now to perform the Torricellian experiment, and to talk about the pressure of the atmosphere, it was a subject which, less than two centuries ago, struck with astonishment all the learned throughout Europe. So wonderful and incredible did it at first appear, that it was not till after the lapse of several years—till after opinions which had prevailed for ages had been overturned, and the most decisive experiments had been performed, in every possible way, that it was cordially received. And, indeed, when we consider the effects of this powerful agent, in the numerous operations both of nature and art, there is something which tends to excite our admiration more than all the fairy tales which the human fancy has created. We behold its operation in compressing the bodies of all animated beings—in counterpoising the internal pressure of the

circulating fluids, and preventing the elastic force of the internal air from bursting the arteries and veins. We behold its operation in forcing-pumps and fire-engines—in raising water from deep pits, and carrying it to the tops of the highest buildings—in giving motion to our spinning-machines, and in propelling large vessels along seas and rivers—in the action of Hiero's fountain, of syphons and barometers; and in many other cases where its agency could scarcely have been suspected. What can be more unlike than the working of a fire-engine, when spouting a column of water to the top of a building in flames, and the crawling of a fly upon a window-pane, or the ceiling of a room? Yet both these operations are performed by the same means, the pressure of the atmosphere.

But what appears no less striking than such operations, is, the pressure of the atmosphere upon our own bodies. It has already been stated, that this pressure amounts to above thirty thousand pounds. Were the half of this weight to fall on one side of our bodies, without being counteracted by any other power, it would produce an effect similar to that of a heavy wall, or the roof of a house falling flat upon us, and would infallibly drive the breath from our lungs, and crush to pieces every bone. What is it, then, which prevents such a terrible effect? A small quantity of air within us, which would not weigh above a single ounce, by its strong elastic force, counterpoises the effects of this tremendous pressure; so that, instead of lying as a mountain on our loins, it acts like wings to our feet, or like sinews to our limbs. When a flat bottle is empty, and laid on its side, we might imagine that the weight of the air would break it to pieces; but the air which is contained within the bottle, whether stopped or not, has the same power, by its elasticity, to prevent its breaking, as the air without has to crush it to atoms. But, if we apply a syringe to the neck of such a flat bottle, and exhaust the air which is enclosed within, the extraction of that small body of air, which, by its elastic spring, supported the sides of it, gives room to the external air to act on the surface of the bottle with all its force, and the bottle will fly into a thousand pieces. Such would be the case with respect to our own bodies, if an exact balance were not kept up between the pressure of the atmosphere without, and the elastic force of the air within; and, in this instance, as well as in a thousand other instances, we have a striking evidence both of the wisdom and of the benevolence of Him who at first created and arranged all the powers and elements of na-

ture, so as to render them subservient to the preservation and comfort of every species of animated existence.

It is owing to the same admirable arrangement of the Creator, that our dwellings are not crushed to atoms. Suppose an apartment only twelve feet square, and nine feet high, the pressure of the air upon the four sides, and the roof, containing five hundred and seventy-six square feet, is equal to one million, two hundred and forty-four thousand, one hundred and sixty pounds! This enormous pressure is balanced by the resistance of the small quantity of the air in the room, which weighs only ninety-seven pounds; so that, here is a small weight of ninety-seven pounds counteracting a pressure of 1,244,160 pounds! Without this wonderful balance no house could be habitable, no creature could remain alive; our glass-windows would be shattered to atoms; an army-tent, a peasant's house, or a shepherd's hut, yea, even our most stately edifices, would be crushed to atoms.

It appears, then, that we are immersed in an invisible fluid, which, on the one hand, by its enormous pressure, threatens to crush us to the earth, and, on the other, by its elastic force, to burst our blood-vessels, and tear our whole frame to pieces. The equality or equipoise of these two formidable and death-menacing powers, is our only safeguard and defence; and shows us how "fearfully and wonderfully" we are every moment preserved by that Almighty Being, "in whose hand our breath is, and whose are all our ways." Here we have a striking evidence of its benevolence and skill, in having, by his wisdom, reconciled and balanced two such formidable and contending powers, and so tempered them, that the impetuosity of the one is checked by the activity of the other; and all nature, instead of being shattered and destroyed, is preserved in safe and harmonious order. Were it his design to destroy the inhabitants of our world, or to render them miserable, we see how easily this could be effected. He has only to permit one of those powers now described to act without control, and the work of destruction is at once accomplished. So that in his "hand is the soul of every living thing, and the breath of all mankind." He upholdeth our souls in life, and his merciful visitation sustains our spirits. It is the province of true philosophy to trace the attributes of the Almighty, in every part of his operations, in the system of nature; and there is no scene throughout the universe, where his voice is not heard, and where his power and wisdom are not conspicuously displayed to those who have ears to hear, and eyes to see, and spiritual discernment to recog-

nise the footsteps and the agency of an almighty, though invisible, Intelligence; "for in Him we live, and move, and have our being."

CHAPTER IV.

THE ELASTICITY OF THE AIR, AND THE PHENOMENA IT EXPLAINS.

The atmosphere is that ocean of air which surrounds our globe on all sides, and in which we live and breathe. We are plunged into the bottom of the vast aërial sea, as the fishes are plunged into the depths of the ocean. Before we were brought into the world, we were furnished with a diaphragm and lungs, with cartilages, ribs, and muscles, to enable us to draw in this vital fluid. The first rush of the air into the lungs, and the cries which accompany, it announce life and sensation. More than a hundred muscles are employed in drawing in and expelling this aërial fluid; and this operation is continued, without intermission, till death. In this element we pass the whole of our existence, from the cradle to the grave; it surrounds us wherever we go, whether on sea or land, and almost all our enjoyments depend on its benign agencies. This element, however, is impalpable to our senses. By its transparency, it escapes our ocular inspection; by its thinness, it eludes our grasp; it cannot be perceived by our smell or taste, nor even by our organs of hearing, unless when it is in a state of tremor and agitation. But we are fully assured, in numerous instances, that the powers of nature may be in complete existence, though they are imperceptible to every organ of sensation; and hence we ought to guard against an error common both to the vulgar and to philosophers, that "the things which we cannot see, have no real existence." The atmosphere, though invisible, is one of the most important and essential constituents of our terrestrial habitation. We could live for a few days without food, or drink, or sleep; we could pass weeks and months without the light of the sun, or the glimmering of a star; but if we are deprived only for a few minutes of the vital air, the lungs refuse to play, the heart ceases to beat, the blood stagnates in the arteries and veins; we faint, we sicken, we die. The powers of the

animal machine are broken; the thoughts and perceptions vanish; the dust returns to its kindred dust, and the spirit returns to God who gave it.

We shall now chiefly attend to the illustration of the elasticity of the atmosphere. By the elasticity of the air, is meant that property by which it contracts itself into less space, when an additional pressure is laid upon it, and by which it recovers its former dimensions when the pressure is removed. When I take a piece of whalebone, or a watch-spring, and bring the two ends together, as soon as the force thus employed is removed, the spring returns to its former position. In such cases, we say that the body is elastic. When I take a small quantity of wool into my hand, and compress it, upon opening my hand, it recovers its former bulk, by the natural spring of its fibres; and hence we conclude that this substance possesses a certain degree of elasticity. In like manner, if I take a bladder and fill it with air, and apply a force to the sides of it, so as to compress it into a smaller space, when the force is removed it immediately expands, and fills the same space as before, which clearly proves that the air contained in the bladder is of an elastic nature.

In consequence of this elastic property, the air always endeavours to expand itself, and to occupy more space. This is proved by taking a bladder, containing only a small quantity of air, tying its neck close, so as to prevent the escape of the air, and then placing it under the receiver of an air-pump. So long as the bladder is exposed to the pressure of the atmosphere, it will remain in the same state; but, when the air is exhausted from the receiver, and the external pressure removed, the side of the bladder, which was flabby and lax, stretches itself out, swells, and becomes tight, being raised by the elastic power. And, if the air be again let into the receiver, the bladder returns to its former shape. By a similar experiment it is shown, that the expansive power of the small quantity of air in the bladder is capable of raising leaden weights of a considerable size. In consequence of this strong elastic power of the air, a person, by blowing into a pipe connected with several bladders, has been able sensibly to raise a mill-stone, which was placed upon the bladders; which demonstrates the very strong expansive power of a very small quantity of air.

On the same principle, were a bladder, containing a very small quantity of air, taken to the higher regions of the atmosphere, it would gradually expand the higher it was carried, in consequence of the pressure of the atmosphere being gradu-

ally diminished, till, at length, it would burst the bladder, by the expansive force with which it is endued. In like manner, heat increases the elasticity of air. If a bladder, containing a small quantity of air, be placed, before a strong fire, the small portion of air it contains will expand, till the bladder appears quite full, and ready to burst. There is another striking experiment which demonstrates this elastic force of the air. When a thin bottle with flat sides is firmly corked, so as to prevent the included air from escaping, is placed under the receiver of an air-pump, and the air exhausted, the spring of the air within it will dilate with so much violence as to break the bottle to pieces. In like manner, were the pressure of the external air completely removed from our bodies, and the escape of the internal air prevented, the elastic force of the air within us would immediately tear the lungs and other vessels to pieces, force the blood through the arteries and veins, and put an end to all the functions of the animal machine. If an animal, as a cat, mouse, or bird, be put under a receiver, and the air exhausted, the animal will be at first oppressed as with a great weight, then grow convulsed, their bodies will swell, and if they are allowed to remain only for a few minutes, they inevitably die. Were we to take a shrivelled apple, and put it under the receiver of the air-pump, and exhaust the air, the skin will gradually swell as the pressure of the air diminishes, the wrinkles will be filled up, and the apple will appear as if fresh-gathered. When the air is let in, it returns again to its former withered state. The effect now stated, is owing to the elasticity of the air in the inside of the apple, which expands when the atmospheric pressure is removed.

From a variety of experiments it is demonstrated, that the spring of the air is equal to its weight, and produces the same effects as its pressure; for, action being equal to re-action, the force which the elasticity of the air exerts, in endeavouring to expand itself, is equal to the force with which it is compressed, just as it is in the spring of a watch, which exerts no force, but in proportion as it is wound up. If a quantity of air, therefore, is included in a vessel, and is of the same density with the surrounding air, its pressure against the sides of the vessel is equal to that produced by the external atmosphere. Hence it is that we can break a square glass bottle, either by the direct pressure of the atmosphere, after the air has been extracted from it, or by removing the pressure of the atmosphere, and allowing the elasticity of the air within to exert its expansive force.

It is owing to the elasticity of the air that it is susceptible of dilatation and compression. To what degree air of the same density which it possesses at the surface of the earth is capable of being compressed, has not yet been fully ascertained. Dr. Halley informs us, that he has seen it compressed, so as to be sixty times denser than in its natural state. Some have supposed that no bounds can be fixed to the condensation of air. But it appears from some experiments made in London, and by the Academy of Florence, that no force whatever is able to reduce air into eight hundred times less space than that which it naturally possesses at the surface of the earth. It is owing to the power of being artificially condensed, that forcing-pumps produced their effects, and that an air-gun is enabled to discharge a ball to a considerable distance with great violence. The air is forced into a certain compartment of the gun by means of a syringe or condenser, which drives the air in, and suffers none of it to come back till it be sufficiently condensed. When the valve which confines the air is opened, the air by its elastic power rushes in behind the ball, and forces it out of the barrel with great violence. It would be better for mankind, however, that no such instruments were ever constructed. Science ought always to have for its object the construction of instruments and machines which have a tendency to promote the comforts of mankind, not those which may be employed by unprincipled men as weapons of destruction; and, therefore, the construction of this instrument is alluded to merely as an illustration of the powerful effect of the elasticity of the air. Would to God that guns, and cannons, and warlike instruments of all descriptions were for ever unknown among men; that swords were beaten into ploughshares, and spears into pruning-hooks; that nation might no longer lift up sword against nation, but delight themselves in peace!

The dilatation or expansion of air, in virtue of its elastic force, is found to be very surprising. In several experiments made by the honourable Mr. Boyle, it dilated at first into nine times its former space, then into thirty-one times, then into sixty, and then into one hundred and fifty. Afterwards, it was brought to dilate 8,000 times its space, then into 10,000 times; and, at last, into 13,679 times the space it originally occupied, and all this was effected by its own expansive force, without the help of fire, or the principle of heat. Hence it appears that the air we breathe near the surface of the earth is compressed by its own weight into at least the 13,000th part of the space it would occupy *in vacuo*. And,

as it has been found that it may be compressed into a space sixty times less than that which it generally occupies, it follows, that the space which it will possess, when most dilated, to that which it occupies when condensed, will be nearly as 820,000 to one ! The amazing force of this elastic power of the air, were it properly directed, might be made to act as a strong mechanical power, and there can be little doubt that many of the terrific operations of nature—such as earthquakes, volcanoes, the rising of new islands from the bottom of the ocean, and the detachment of rocks and fragments of mountains amidst the ranges of the Alps, the Andes, and other mountainous regions—are to be ascribed, at least to the partial operation of this power, in combination with other physical agents.

It has been a subject of inquiry among philosophers, whether the elastic power of the air is capable of being diminished or destroyed. Mr. Boyle endeavoured to discover how long air would retain its spring, after having assumed the greatest degree of expansion his air-pump could give it, but he never observed any sensible diminution. Mr. Desaguliers says, that air, which had been inclosed half-a-year in a wind-gun, had lost none of its expansive power ; and Mr. Roberval asserts that he has preserved air in the same manner for sixteen years; and after that period, he observed that its projectile force was the same as if it had been newly condensed.

Various causes have been assigned by philosophers to account for the elasticity of the atmosphere. The general opinion which now prevails is, that it depends upon the latent caloric, or principle of heat, which it contains, and which enables it to retain its fluid form ; and that caloric is the most elastic body in nature. But this is only an explanation of elasticity by an assumption of elasticity. It removes the difficulty only one step farther on, and leaves us still in the dark as to the nature of elasticity, and the reason why caloric is endowed with an elastic power. In this, as well as in many other instances, we must rest contented in resolving it into the will of the Deity, that such a property should be possessed by atmospheric air in order to accomplish some wise and beneficent purposes in the economy of creation.

The elasticity of the air explains a variety of appearances in nature and art. For example, beer or ale, when bottled, contains in it a quantity of air, the elasticity of which is resisted by the pressure of the condensed air between the cork and the surface of the liquid. On removing the cork, the liquid and the air which it contains are relieved from this in-

tense pressure. The liquid itself, not being elastic, is not affected by this; but the elastic force of the condensed air, which has been fixed in it, having no adequate resistance, immediately escapes, and rises in bubbles to the surface, and produces the frothy appearance consequent upon opening the bottle. On a similar principle we may account for the following appearance. If a man fall into the water, and is drowned, the carcase in a few days rises and floats on the surface. The privation of life, and the stagnation of the fluids, are soon followed by a putrid fermentation, which decomposes the body. This fermentation disengages a great quantity of air, which is disseminated among the internal vessels, and as this air cannot escape, the body swells by its expansion, till it becomes specifically lighter than the water, and rises to its surface. But, as the putrefaction goes on, the parts give way, the air escapes, and the body, being thus rendered specifically heavier than the water, sinks to rise no more. It is likewise by the elastic property of air that fishes are enabled to rise and sink in the water. They are furnished with an air-bladder, which they have the power of contracting or dilating at pleasure. When the fish compresses this bladder, its whole volume becomes less, and it sinks in the water; when the pressure is removed, the air in the bladder instantly expands, and it is enabled to rise to the surface. A variety of instances of a similar kind, illustrative of the elasticity of the air, might be exhibited: but instead of dwelling on these, we shall now proceed to another department of our subject.

CHAPTER V.

THE HEIGHT OF THE ATMOSPHERE; OR, THE ELEVATION TO WHICH IT EXTENDS BEYOND THE SURFACE OF THE EARTH.

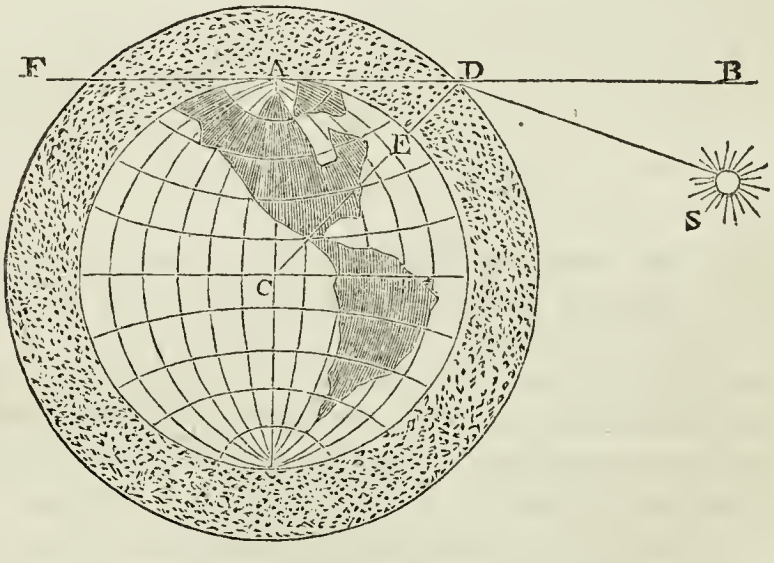
The height of the atmosphere is considered, by many writers and lecturers on this subject, as a point fully determined, and is treated as familiarly as the height of the Andes, or the Alps, or of Mount Etna, or Mount Blanc. But the height of the atmosphere has never yet been fully ascertained, and it is probable will never be accurately determined. If, indeed, the air were of an equal density, from the surface of the earth to the top of the atmosphere, its height might be

easily determined; for it is found by experiment, that the weight of a column of air extending to the top of the atmosphere is equal to the weight of a column of water of the same base and 32 feet high. Supposing water to be 840 times heavier than air—multiply 840 by 32 feet, and the product will be 26,880 feet, or 5 miles and 160 yards for the height of the atmosphere, were its density at every elevation exactly the same as at the surface of the earth. But we know that the density of the air decreases and is more rarefied and expanded the higher we go; and, from other considerations we know that it extends far beyond the limit now stated; so that this calculation can afford us no accurate idea of the height to which the atmosphere extends.

Another method, therefore, of determining this point was devised by philosophers, which approaches nearer to the truth. It is found by observation, that the sun is about eighteen degrees below the horizon before twilight comes to an end in the evening. Now, twilight is caused by the rays of the sun being refracted and reflected from the higher parts of the atmosphere to the earth; otherwise, we should be involved in total darkness at the moment the sun descended below the horizon. From this circumstance, the height of the highest part of the atmosphere which is capable of refracting the rays of light may be determined.

Let F A B (fig. 5) represent the horizon of an observer at A; S D, a ray of light falling upon the atmosphere at D, and making an angle, S D B, of 18° with the horizon; the angle S D A

Fig. 5.



will then be 162°. From the centre C, draw C D, and it will be perpendicular to the reflecting particles at D, and will likewise bisect the angle S D A. In the right-angled triangle

C D A, the angle C D A is equal to 81° ; or, if we allow for refraction, 81° 30′, A C, the radius, or half-diameter of the earth, is nearly equal to 400 miles. Then by the rules of trigonometry,

As the sine of the angle C D A	81° 30	9.995203
Is to the side A C,	4000	3.602060
So is radius, sine of 90°		10.000000
To the side C D, 4044½ miles		3.606857

From C D, equal to the semi-diameter of the earth and atmosphere, subtract C A, or the semi-diameter of the earth, and the remainder, E D, equal to 44½ miles, will be the height of the atmosphere. In this operation, the logarithms of the second and third terms of the proportion are added, and the logarithm of the first term subtracted from the sum.

Thus 3.602060
10.000000

13.602060
9.995203

3.606857

The same result is produced by the following proportion :—

As Radius	10.000000
Is to A C 4000	3.602060
So is the secant of A C D = 8½°	10.004800
To C D = 4044½	3.606860

It appears, then, that in ordinary cases, the air, at the height of forty-four miles and a half, is capable of reflecting to us the rays of light. But, as a sensible illumination has been perceived when the sun is much further below the horizon than what has been now stated, there is some reason to conclude, that the air is sufficiently dense for reflecting a sensible degree of light at the height of nearly two hundred miles.

Various considerations, founded on meteoric phenomena, serve to prove that the atmosphere extends to a much higher elevation than forty-four or fifty miles. In the year 1719, a remarkable luminous meteor, or fire-ball, was seen, whose altitude was computed to be seventy-three miles above the surface of the earth. On the 18th of August, 1783, a brilliant fire-ball passed over Britain and the adjacent countries; and, from various circumstances which were particularly marked by different observers, it was calculated that its elevation above the earth could not be less than ninety or a hundred miles. In passing over certain parts of England a loud report was heard and a hissing noise. The meteor of 1719 is said to have been attended with an explosion, which was heard over the whole island of Great Britain, occasioning a

violent concussion of the atmosphere, and seeming to shake even the earth itself. Now, in these, and multitudes of similar phenomena, we have instances of fire and flame being supported, and sounds conveyed to the earth from a height of ninety or a hundred miles; and, consequently, even in these elevated regions, notwithstanding the great rarefaction of the air, it must still have the power of supporting flame and propagating sound. Even although the fire-balls alluded to be supposed to consist of electrical matter—which is the general opinion—yet the difficulty is not thereby removed; for, it is found, by some late experiments, that the electrical fire cannot penetrate a perfect vacuum. And, therefore, there is reason to conclude, that we are still ignorant of the precise extent of the atmosphere, and of the nature of the fluids which occupy its superior regions. That the meteors now referred to, however elevated, were not beyond the limits of the atmosphere, appears from this consideration, that the atmosphere revolves with the earth in its course round the sun, at the rate of 68,000 miles an hour. Now, as the meteor of 1783 moved from north to south, if it had been beyond the limits of the atmosphere, it would have been left, in the course of a minute, more than a thousand miles to the westward, by the earth flying out before it, both in its annual and diurnal course.

In short, it appears not altogether improbable to suppose, that the visible universe is filled with some fine elastic fluid or air, but of such a rarity as to be no sensible hindrance to the celestial orbs in their rapid motions through the regions of space; and that this fluid accumulates itself around every planetary body, in proportion to the quantity of matter it contains—the larger bodies attracting more of it, and the smaller bodies less; and thus forming an atmosphere around each, corresponding to its nature and destination. And, if this be the case, the atmosphere of the earth can have no definite boundary, but may be said to mingle with the atmospheres of all the other planets which belong to our system. There is a certain portion of atmospheric air, however, which must always be considered as attached to the earth, and which revolves with it in its diurnal rotation, and is carried along with it in its course round the sun. If the atmosphere did not revolve along with the earth, we should constantly experience an easterly wind, blowing with an immense velocity of more than a thousand miles an hour, which would produce a most tremendous hurricane, which would level with the ground houses, trees, forests, and every prominent

object on the surface of the earth. But the particular region where the motion of the atmosphere terminates, it is impossible for us to ascertain.

CHAPTER VI.

THE COMPOSITION OF THE ATMOSPHERE.

For a long series of ages, air was considered by philosophers as one of the four elements of which all things are composed, the other three being fire, earth, and water. But the discoveries of modern chemistry have fully demonstrated that all these are compound bodies—that even the air itself, fine and invisible as it is, is not a simple substance, but compounded of different ingredients. This is one of the most curious and interesting discoveries of modern times; and little more than seventy years have elapsed since it was first surmised that the atmosphere is not a simple and homogeneous, but a compound fluid. The experiments which led to this discovery were first made by Dr. Priestley, on the first of August, 1774, on which day he obtained what was then termed dephlogisticated air, now known by the name of oxygen gas, and which forms one of the constituent principles of atmospheric air. It was also discovered in the year 1775, by M. Scheele, a Swedish chemist, without any previous knowledge of what Dr. Priestley had done, and he gave it the name of empyreal air, from its powerful influence in supporting flame. But, instead of entering into the history of such discoveries, and of the processes by which they were made, a few of the properties possessed by the different ingredients of which our atmosphere is composed may be simply stated.

The air of the atmosphere, then, is found to consist chiefly of two very opposite principles or fluids, termed oxygen gas, and nitrogen gas, along with a very small proportion of fixed air, or carbonic acid gas. If any portion of the atmosphere, such as the air in our apartments, be supposed to be divided into a hundred equal parts, twenty-one of these parts will be oxygen gas, about seventy-eight nitrogen, and a hundredth part, or, according to some chemists, a thousandth part, will be fixed air, or carbonic acid gas. In the first place, a few remarks shall be offered on the nature and properties of oxygen gas.

This gas, like common air, is colourless, invisible, and elastic, and capable of indefinite compression and expansion. Its peculiar and distinguishing properties are:—1st. It is essential to combustion, and is the only principle with which we are acquainted by which flame can be supported. When acting by itself, it produces the most rapid conflagration of all combustible substances. If a lighted taper be let down in a jar of oxygen gas, it burns with such splendour that the eye can scarcely bear the glare of light, and, at the same time, produces a much greater heat than when burning in common air. If a piece of iron wire, a watch-spring, or a steel file, armed with a piece of wood, or phosphorus, in an inflammable state, be put into this gas, the steel will take fire, throwing out sparks, and producing the most brilliant appearance, almost dazzling the eye with their splendour. In the next place, it is essential to the support of animal life; for it has been proved by many experiments, that no animal can exist for a single moment in any kind of air which does not contain a certain portion of oxygen; so that man, and all the other ranks of animated beings, may be said to depend upon this substance, not only for their comforts, but for their very existence.

Again, the basis of oxygen gives the acid character to all mineral and vegetable salts, from which property its name is derived; for the term oxygen literally signifies, the generator of acids. In short, oxygen is the vehicle of heat to the animal system—it imparts the red colour to the blood in its passage through the lungs—it constitutes the basis both of the atmosphere which surrounds the earth, and of the water which forms its rivers, seas, and oceans; for water is found to be nothing else than a combination of two kinds of air, oxygen and hydrogen gas. It pervades the substance of all the vegetable tribes, and enables them to perform their functions. In combination with the different metals, it serves the most important purposes in the useful arts; and, on the whole, may be considered as the most extensively useful, and the most powerful and energetic agent in the system of nature.

Oxygen gas may be procured from a variety of substances, particularly from nitre, manganese, and the red oxyde of mercury, and also from vegetables immersed in water and exposed to the solar rays. It is heavier than common air, nearly in the proportion of eleven to ten; one hundred and sixteen cubic inches of oxygen are found to weigh about thirty-nine grains, while the same quantity of common air weighs only thirty-five and a half grains.

One of the most extraordinary effects of oxygen appears when it is combined with nitrogen in a certain proportion, so as to form what is commonly called nitrous oxyde. This gas consists of sixty-three parts nitrogen and thirty-seven parts oxygen. When it is put into a bladder, and inhaled into the lungs, by means of a pipe, and shutting the nostrils, it produces an extraordinary elevation of the animal spirits—involuntary muscular motion—a propensity to leaping and dancing—involuntary bursts of laughter—a rapid flow of vivid and agreeable ideas, and a thousand delightful emotions, without being succeeded by any subsequent feelings of languor or debility. When Mr. Southey, the poet, inhaled this gas, he declared that it produced in him sensations perfectly new and delightful. His first sensations were a kind of dizziness, so as to produce a fear of falling. This was succeeded by a laugh, which was involuntary but highly pleasurable, accompanied with a peculiar thrilling in the extremities perfectly new, and with the most delightful sensations. For many hours after this experiment, he imagined that his taste and smell were more acute, and is certain that he felt unusually strong and cheerful.

In Professor Silliman's *American Journal of Science*, we have the following account of the effects of this air on one of the professor's students, at Yale College, New Haven. "The person on whom the experiment was made, was a man of mature age, and of a grave character. For nearly two years previous to his taking the gas, his health was so very delicate, and his mind so gloomy and distressed, that he was obliged almost entirely to discontinue his studies. In this state of debility, he inhaled about three quarts of the nitrous oxyde. The consequences were, an astonishing invigoration of the whole system, and the most exquisite perception of delight. These were manifested by an uncommon disposition for mirth and pleasantry, and by extraordinary muscular power. The effects of the gas were felt without diminution for at least thirty hours; and, in a greater or less degree, for more than a week. But the most remarkable effect was upon the organs of taste. Before taking the gas, he felt no peculiar choice in the articles of food; but, immediately after that event, he manifested a taste for such things only as were sweet, and, for several days, ate nothing but sweet cake. His singular taste was, indeed, carried to such excess, that he used sugar and molasses, not only upon his bread and butter and lighter food, but even upon his fresh meat and vegetables; and this he continues to do (says the narrator) at the present

time, although eight days have elapsed since he inhaled the gas. His health and spirits since that time have been uniformly good, and he attributes the restoration of strength and mental energy to the influence of the nitrous oxyde. He is quite regular in his mind, and now experiences no uncommon exhilaration, but is habitually cheerful, whereas, before, he was habitually grave, and even, to a degree, gloomy and melancholy."

The writer has inhaled this gas, and can attest its pleasing and exhilarating effects. It produced a disposition to laughter, which no consideration could resist, and a wish to flee from the apartment in which the experiment was performed, that laughter might be indulged without restraint. It produced, likewise, an agility and a tendency to skip and jump; and, during its effect, a flow of pleasing ideas passed through the mind, and the lapse of a few seconds seemed to be magnified into as many hours. He has witnessed its effects both on the male and on the female sex. He has seen a little grave man, possessed of a meek and well-cultivated mind, capering through the room with all the airs of a king, brandishing his staff, and jumping till his head nearly touched the ceiling of the room, about eight feet high. When, afterwards, asked why he brandished his stick, as if he had been going to fight, he replied, that he imagined there was a beautiful and extensive scene before him, which he wished to approach; but was prevented by the company around him, and, therefore, was obliged to clear his way, like a policeman when keeping off a crowd. The writer has, also, seen a female rapt into perfect ecstasy in consequence of the feelings she experienced, expressing her emotions in the most poetic exclamations, and tossing her shawl, her head-dress, and her slippers, from her as unworthy of attention, and altogether regardless of the looks and opinions of surrounding spectators. But, in order that this gas may produce its full effect, it requires some attention and dexterity in breathing it. The nostrils must be stopped, and no atmospheric air, if possible, should be allowed to mix with the nitrous oxyde. For want of attending to such precautions, some persons who attempt to breathe it, never felt its peculiar effects.

It has been ascertained from various experiments, particularly from those made by the late Sir Humphrey Davy, that the nitrous oxyde produces a somewhat similar effect upon insects, and other animals, which are found to jump and caper about in a frolicsome manner, as if highly delighted, when immersed in this gas.

These, and other effects, arising from the breathing of this very singular fluid, show us with what ease the Almighty could produce in us either the most delightful or the most painful sensations, merely by a slight modification or change of the principles of which the atmosphere is composed. Certain combinations of oxygen and nitrogen gas would produce a fluid, which would inflict the most excruciating pain, and destroy the corporeal system in a few minutes. Sulphuric acid, or aquafortis, a most deadly fluid, when taken into the mouth or stomach, is composed of seventy-five parts oxygen and twenty-five parts nitrogen, which is only a different proportion of the same ingredients which constitute the air we breathe. Were, therefore, our atmosphere composed of such a proportion of these two gases, it is easy to foresee the fatal consequences which would result from breathing such a fluid. On the other hand, we may learn how an intelligent mind connected with a corporeal frame, somewhat analogous to ours, may be preserved in a state of uniform cheerfulness, and even of exquisite delight, by breathing an atmosphere somewhat similar to that of nitrous oxyde. In other worlds, where the inhabitants have retained their original integrity, this may be the case. The other planets of our system or of other systems, although encompassed with atmospheres, may have them of very different qualities from ours, as to their transparency, their refractive and reflective powers, and the influence they produce on the mental and corporal constitution of their inhabitants. Our atmosphere exhibits evident marks of Divine wisdom and benevolence; but it is adapted to man considered as in a state of depravity and imperfection, and appointed to a short mortal existence, and is not fitted to preserve him in an immortal existence in the present state, as was probably the case when this world was first arranged, and when man proceeded from the hands of his Creator as a holy being.

The next component part of the atmosphere is nitrogen gas, or what is sometimes termed azote. It is chiefly distinguished by its negative qualities. In the first place, no combustible body will burn in it; for, if a burning candle be immersed in a jar filled with nitrogen, it will be extinguished as instantaneously as if plunged in water. If a lighted taper be put into a close vessel full of common air, it will burn till all the oxygen be consumed, after which, as nothing but nitrogen remains, it will instantly go out. In the next place, it is incapable of supporting animal life; for, if any living being be obliged to respire it, it drops down dead almost instantaneous-

ly ; and, from this circumstance it derived the name of azote, which signifies life-depriver. It is this gas which passes from the lungs at every expiration ; and, were we to breathe it again, without any mixture of other air, we should be instantly suffocated. But, being lighter than atmospheric air, it rises above our heads, and enters into new combinations. It is owing to the presence of this gas, rising from several hundreds or thousands of lungs, that candles burn so dimly in the higher parts of crowded churches and assemblies. It is, therefore, a striking consideration, that nearly four-fifths of the air we breathe consist of this noxious and destructive fluid. But, though it is destructive to animal life, it forms an important element in the system of nature : it enters extensively into combination with other substances ; and its existence in such a large quantity is a chief distinction between the constitution of animal and vegetable matter. It likewise exists in the products of several vegetables, and appears to be favourable to plants and flowers, which vegetate freely when surrounded with nitrogen. This gas is permanently elastic, transparent, colourless, and inodorous. Its specific gravity is 0·9748, that of common air being 1·0000 ; and one hundred cubic inches of it weigh about thirty grains. It slightly tinges delicate blue colours with green.

The other ingredient mentioned as forming a small portion of the atmosphere, is carbonic acid gas, or what was formerly called fixed air. This gas constitutes about a hundredth, or, according to some chemists, about a thousandth part of the atmosphere. It is found in a state of combination with limestone, chalk, marble, manganese, and other substances, from which it may be extracted by the application of heat, or of the mineral acids, and in considerable abundance in mines, caves, the bottom of wells, in wine-cellars, brewers' vats, and in the neighborhood of lime-kilns. It is invisible and elastic, and is the heaviest of all the gases, being considerably heavier than common air ; and, therefore, may be poured from one vessel to another, like water. Its specific gravity is 1·5123, that of common air being reckoned 1·0000, so that its gravity is more than one and a half that of atmospheric air. One hundred cubic inches of oxygen weigh nearly thirty-four grains, while one hundred cubic inches of carbonic acid weigh more than forty-six and a half grains. It is this gas which has deprived of life many individuals who have descended into deep wells which had been long shut up from the air, and which produces so many ravages in coal-mines, under the name of the choke-damp ; for

it is almost instantaneously fatal to all animals that breathe it. Wherever it is found, it always occupies the lowest place, on account of its superior weight; and, therefore, in those caves where it abounds, a person may walk erect without danger; but, were he to lie down, he would be instantly suffocated. The Grotto del Cani, or the Dog's Grotto, in Italy, is well known. It is an artificial cave, in which there is a constant natural exhalation of carbonic-acid gas. The following feat is shown to strangers:—A man carries in a dog, and places him on the floor; the dog, if left long enough, dies; but the man is not affected; for the carbonic-acid gas, by its weight, occupies the lowest stratum of about eighteen inches depth, and the stratum above that height is pure air. But that it is poisonous to man, is evinced by the fate of persons who incautiously expose themselves to the vapours of charcoal burning in ill-ventilated apartments, or who venture into large vessels, in which fermentation had been conducted, as in breweries and distilleries. Many persons, from ignorance of the prevalence of this gas in the vicinity of lime-works, have lain down to repose, and in a short time have slept the sleep of death. As this gas is destructive to animal life, so it extinguishes flame. This can be strikingly shown by letting down a burning taper to the bottom of a glass jar, filling a bottle with carbonic-acid gas, and pouring it as if it were water into the jar; the flame is immediately extinguished. It is this gas which gives briskness and an agreeable pungency to fermented liquors, as porter and ale, and which appears on their surface in the form of a white froth. All kinds of spring and well water contain carbonic acid, which they absorb from the atmosphere, and to which they are partly indebted for their agreeable flavour. Boiled water has an insipid taste from the absence of carbonic acid.

The base of carbonic-acid gas is distinguished by the name carbon, which is nearly allied to charcoal. It exists largely in animal substances, and is extensively distributed in the mineral kingdom. The only body in which carbon has been found to exist in a state of absolute purity, is the diamond—a precious stone which has always been esteemed as the most valuable of the gems; a superiority which it owes to its hardness, lustre, and high refractive power. It uniformly occurs crystallized, and presents a great variety of forms. Its specific gravity is 3·5, water being 1. Its hardness is extreme, so that it can be worn down only by rubbing one diamond against another, and is polished only by the finer diamond powder. The diamond, by being intensely heated with a

burning-glass in oxygen gas, burns with a bright red light, and converts the oxygen into pure carbonic-acid gas, as charcoal does. Carbonic-acid gas is, therefore, to be considered as a solution of diamond in oxygen gas, even when it is prepared by the combustion of mere charcoal. It may not be altogether useless to remark, that in all places, such as wine-cellars, vaults, and deep wells, where the presence of carbonic-acid gas is suspected, it is proper to use the precaution of trying whether a candle or taper will burn in such places before we venture into them. If it be a deep well that requires to be cleaned, a burning candle should be let down with a cord, and if it go out before reaching the bottom of the well, no person ought to venture down before the noxious air is removed.

Such, then, are the three constituent principles of the atmosphere in which we live and breathe. We ought not, however, to conceive that the principles which form our atmosphere, and the proportion in which they are combined, constitute the only fluid which is fitted for supporting animal life and vigour. It is a fluid which seems to be adapted only to mortal men, and calculated to support the vital functions only to the period of eighty or one hundred years. It is not at all improbable, that it is owing to the large proportion of nitrogen which enters into the composition of the atmosphere that renders it unfit for supporting human life beyond a certain short and limited period; and that, were a much larger quantity of oxygen combined with other gases, in a certain proportion, and some slight changes effected in the other elements of nature, the lives of men and other animals might be protracted to several hundreds or thousands of years, and their spirits preserved, at the same time, in uninterrupted cheerfulness and vigour. Nor is it altogether improbable that, in the course of those improvements which are now commencing throughout the world, the air of our atmosphere may be greatly ameliorated, and rendered more salubrious and invigorating to animated beings, when the stagnant marshes which abound in every part of the globe shall be completely drained; when those immense forests which now cover a great part of Asia, of New Holland, and of the continent of America, shall be cut down, and the soil laid open to the influence of the solar rays —when the reefs which are now rising from the ocean, by the agency of minute creatures, shall be formed into continents and islands—when the barren deserts of Africa shall be transformed, by human science and industry, into fruitful fields—when the soil throughout every region of the globe

shall be universally cultivated—when those immense thickets and jungles where the lion and the tiger now roam undisturbed, shall be changed into corn-fields, gardens, and orchards, and become the seats of civilization and of peace—in short, when the whole earth shall form one wide scene of rural and architectural beauty—we have every reason to believe that then the different climates of the earth will be greatly meliorated; that the fury of those storms which now carry destruction in their train will be greatly abated—and that the very atmosphere round us will be so modified, purified, and improved, so as to render it capable of prolonging the life of man for perhaps two or three hundred years. Such effects correspond to what is predicted respecting the state of the world during the millennium, when the instruments of warfare shall be beaten into plough-shares and pruning-hooks; when peace shall reign triumphant over the world, and when every man shall sit under his vine and fig-tree without fear of annoyance. At which period it is predicted, that the life of man shall be extended beyond its present boundaries. For thus saith Jehovah, "As the days of a tree* are the days of my people"—"they shall build houses, and inhabit them; and they shall plant vineyards and eat the fruit of them; . . . and mine elect shall long enjoy the work of their hands." "Then shall the earth yield her increase; and God, even our own God, shall bless us."

All the operations and ameliorations now alluded to are perfectly practicable, were the moral state of man improved. Could we undermine the principle of avarice and selfishness in the human heart; could we promote a spirit of harmony and general benevolence among human beings; and were the whole body of mankind to exert their powers in unison, in the cause of universal improvement—this earth, which, in many places, appears like a world in ruins, might, ere long, be transformed into one wide terrestrial paradise. But principles and dispositions directly opposite to these have, for the most part, hitherto prevailed. The present state of the moral world, and the infernal passions which have raged among mankind for ages past, have rendered it expedient, in the moral government of the Almighty, that the life of man should not extend much beyond "threescore years and ten," in order that wickedness may be kept within certain bounds. And, therefore, no extraordinary or extensive improvements in science and art, or in the general cultivation of the earth, can be expected

* Certain species of trees are said to continue in vigour during a period of five hundred years, as the oak and several other trees.

till the moral powers of man be cultivated and improved along with the intellectual; till the religion of Jesus be universally recognised in all its bearings; till its holy principles and practical precepts pervade every heart; and till a spirit of love, kindly affection, and benevolence distinguish the general mass of society in every land.

But, to return from this digression, it may be further remarked, that it is highly probable that the component parts of the atmosphere, in the ages before the flood, were very different from what they now are, and that it was owing to the peculiar constitution of the air which then existed, that the lives of the antediluvians were prolonged to nearly a thousand years. At the period of that awful catastrophe, when the fountains of the great deep were broken up, and the windows of heaven were opened, and the solid strata of the earth disrupted, it is probable that the atmosphere, too, underwent an important change by the dissolution of some of its elementary parts, so that it had a tendency to cut short the lives of mankind in all succeeding ages; and, till the ruins which were produced by that physical convulsion be in some measure repaired, the same cause will produce the same effects.

In short, an atmosphere is not peculiar to the globe on which we dwell. We know, from observation, that the planets Mars, Venus, and Jupiter, are furnished with atmospheres; and it is probable that every planetary world has a similar appendage. But their nature may be as different from ours as are the nature of their inhabitants and the constitution of the globes on which they reside. While our atmosphere is fitted only to prolong the lives of mortal men for a limited number of years, the atmospheres of some of the other planets may be so impregnated with the vital principle as to support immortal bodies in undecaying vigour, and to cause such an elevation of spirits as will produce uninterrupted ecstasy and delight. And all this may be effected by the same elementary principles of which our atmosphere is composed, but differently modified and compounded by the hand of the Almighty. The experiments with nitrous oxyde, formerly mentioned, show us what striking effects may be produced by different combinations of the gaseous fluids; and, therefore, it is not improbable that the atmospheres of all the worlds in the universe are only different modifications of these substances, suited to the constitutions of their inhabitants, and the spheres they occupy in creation. In the operations of the Almighty throughout the system of nature, we perceive a striking simplicity in the means, producing an infinite variety of asto-

nishing results. From a few simple substances—caloric, light, water, air, and carbon—are produced all the diversity of forms and colours which appear among the sixty thousand species of plants which adorn the vegetable kingdom, and almost all the diversified phenomena of sublunary nature. And it is not unlikely that different combinations of these, and a few other substances, produce all that variety which appears throughout the boundless universe; and may give birth to all the changes and revolutions through which the different systems of creation may pass during every period of infinite duration. For He who arranged the system of universal nature "is wonderful in counsel, and excellent in working"—"his wisdom is unsearchable," his power irresistible, and the ways of his providence "past finding out."

CHAPTER VII.

THE BENEFICIAL EFFECTS OF THE ATMOSPHERE IN THE SYSTEM OF NATURE.

This subject presents an immense field of contemplation, which it would require several volumes fully to illustrate: and, therefore, a few general statements and illustrations can only be given.

1. In the first place, air is essentially requisite to the germination and growth of plants; and, therefore, to the influence of atmospheric air all the beauties of the vegetable creation are to be chiefly ascribed. By experiment, it is found that the access of atmospheric air is no less necessary for plants than it is for the continuation of animal life. Like animals they are found to die when confined within a vacuum, or deprived of the vital air. The influence of the atmosphere is equally essential at every period of their existence, from the germination of their seeds to the full development of all their organs in the perfect plant. Their leaves, acting in some measure like the lungs of animals, absorb oxygen gas during the night, and carbonic-acid gas during the day; and this alternate process is found to be essential to their growth and nourishment. Even the green colour of plants, which is produced chiefly by the influence of light, is proved not to be perfected without the co-operation of oxygen gas. It is found

that pure air, or oxygen gas, may be procured by putting the leaves of plants into water, and exposing them to the sun. In purifying contaminated air, Dr. Priestley discovered that vegetables answered this purpose most effectually. Having rendered a quantity of air very noxious, by mice breathing and dying in it, he divided it into two receivers, inverted in water, introducing a sprig of mint into one of them, and keeping the other receiver, with the contaminated air in it, alone. He found, in about eight or nine days after, that the air of the receiver into which he had introduced the sprig of mint had become respirable; for a mouse lived very well in this, but died immediately upon being introduced into the other receiver, containing the contaminated air alone. It is likewise proved by experiment, that the simple component principles which are essential to the formation of vegetable matter are but three in number, namely, carbon, oxygen, and hydrogen; and these form the bases of carbonic acid gas, oxygen gas, and hydrogen gas. From the various proportions in which these ingredients are combined, results almost all the variety of vegetable matters which fall under our notice.

To the atmospheric influence, therefore, we are indebted for all the productions of our fields and gardens, and for all that diversity of prospect and colouring which the vegetable tribes spread over the landscape of the world. It is true, indeed, that water is also necessary for the production of plants. But what is water? It is nothing else than a composition of two kinds of air, oxygen and hydrogen, combined in certain proportions. Now, it is found that plants have the power of decomposing water into these two principles, throwing off a part of the one, and absorbing a part of the other. The elasticity of the air has likewise an important influence on the air-vessels of vegetables; for the contained air, alternately expanding and contracting, according to the increase or diminution of the heat, alternately presses the vessels, and eases them again, thus keeping up a perpetual motion of their juices. It has likewise been ascertained, from recent experiments, that the pressure of the atmosphere has a powerful influence on vegetation, which suggests to us one of those causes which prevent trees from flourishing on the elevated sides of lofty mountains.

2. The pressure of the atmosphere has an influence in preserving water in the state in which we find it. Nothing is of more importance to the comfort of man and other creatures, and to almost all the processes of the arts, than water—without which our globe would be transformed into an immense

desert. But, if there were no atmosphere, all the waters on the face of the earth would boil, and be evaporated with a very slight degree of heat. The ocean would be drained to its lowest caverns, the rivers would cease to flow, the springs would be dried up, and the whole surface of the land exhausted of that moisture so essential to the existence of the animal and vegetable world. Indeed, it is not improbable, that all the substances on the earth, solid as well as fluid, would be dissipated into vapour. That such effects would actually take place, appears from a variety of experiments. If we fill a long-necked bottle with boiling water, and cork it close, so as to exclude the air, and place it in a basin of cold water, the water will sink in the neck of the bottle as it cools. This shrinking of the water will produce a vacuum in the upper part of the bottle, and the water within it will be seen to re-commence boiling with great violence, which can arise from nothing but the cork taking off the pressure of the atmosphere from the water. In like manner, if we place water that has been cooled several degrees below boiling, under the receiver of an air-pump, it will begin to boil as soon as the air is exhausted. It requires a heat of 212° of Fahrenheit's thermometer to make water boil under the common pressure of the atmosphere; but in the exhausted receiver of an air-pump, it boils when heated to only about 67°. The phenomenon exhibited by what is called the pulse-glass, is also owing to the same cause. This glass, having two bulbs, is partly filled with spirits of wine, the air is extracted, and the glass hermetically sealed; and when the hand is applied to one of the bulbs, it causes a heat which produces an ebullition in the spirits of wine. It is likewise owing to this pressure that porter, ale, and other fermented liquors are preserved in bottles; without which they would either rush with violence out of their mouths, or burst them to pieces. It is owing to the same power that boiling water is preserved in our pots and kettles, when used in cooking, without the influence of which it would soon dilate itself, rush over the vessels, and be dissipated into vapour.

3. It is to the atmosphere we are indebted for the action of fire and flame. Fire is essentially necessary to human existence, even in the warmest climates of the globe. By its means the inhabitant of the desert frightens from his dwelling the beasts of prey, and drives away the insects which thirst for his blood. By its means also, man, in every country, prepares his food, dissolves the metals, vitrifies rocks, hardens clay, softens iron, tempers steel, and gives to all the

productions of the earth the form and combinations which his comfort and necessities require. But, without the vital air, no flame can be extricated, nor fire made to burn. This is proved by putting a burning taper within the receiver of an air-pump, and when the air is extracted it is instantly extinguished. The act of combustion effects an analysis of the air; it separates its component parts: the oxygen of the atmosphere combines with the combustible body; caloric, in the form of sensible heat, is thrown off in every direction; and therefore, where no oxygen exists, it is impossible to make even the most combustible body produce heat or flame.

4. It is on the influence of the atmosphere that respiration of all animals depends. The process of respiration is carried on by means of the lungs. These are distinguished into right and left. The right, or larger lung, is divided into three lobes; the left, or smaller, into two. The internal fabric of the lungs is composed of an infinite number of small membranous cells, full of air, communicating with one another, the number of which Dr. Keil and other anatomists have computed to be at least 1,744,000,000, that is, one thousand seven hundred and forty-four millions. The air from without rushes into these vesicles, and is again expelled 1,200 times every hour: and during the same time we consume about 48,000 cubic inches of air, or, at the rate of seventy-seven wine hogsheads in a day. The chief uses of respiration are—1, to bring the blood in contact with the air; 2, to effect certain changes in the mass of the blood; and 3, to produce animal heat. Accordingly, the lungs are so constructed as to allow the largest possible quantity of deteriorated blood to enjoy the fullest intercourse with the largest possible quantity of vital air. It has been calculated by Dr. Hales, that each air-cell is the one-hundredth part of an inch in diameter, and that the amount of surface furnished by them, collectively, is equal to twenty thousand square inches. Others have estimated the surface to be more than 1500 square feet; and Dr. Monro states, that it is thirty times the surface of the human body. From numerous experiments, it has been found that the blood perpetually receives oxygen gas from the atmosphere by the agency of the lungs, and that its red colour is derived from this source. The blood is purple when it arrives at the lungs from the heart; but, having there thrown off hydrogen and carbon, it imbibes the vital air of the atmosphere, which changes its dark colour to a brilliant red, rendering it the spur to the action of the heart and arteries, and the source of motion and of animal heat. The blood is thus in-

debted every moment to the invigorating influence of the atmosphere, without which the heart would cease to beat, the circulating fluids would stagnate, and the body become a cold putrid mass, without sensibility or motion.

The following are some of the results of experiments in relation to this subject, lately performed by Dr. S. Smith. "1. The volume of air ordinarily present in the lungs is twelve English pints. 2. The volume of air received by the lungs, at an ordinary inspiration, is one pint. 3. The volume of air expelled from the lungs at an ordinary expiration, is a little less than one pint. 4. Of the volume of air received by the lungs at one inspiration, only one-fourth part is decomposed at one action of the heart, and this is so decomposed, in the five-sixth parts of one second of time. 5. The blood circulates through the system, and returns to the heart in one hundred and sixty seconds of time, which is exactly the time in which the whole volume of air in the lungs is decomposed. These circuits are performed every eight minutes; five hundred and forty circuits are performed every twenty-four hours. 6. The quantity of blood that flows to the lungs, to be acted upon by the air at one action of the heart, is two ounces, and this is acted upon in less than one second of time. 7. The quantity of blood in the whole body of the human adult is twenty-four pounds avoirdupois, or twenty pints. 8. In twenty-four hours, twenty-four hogsheads of blood are presented to the lungs, to receive the influence of the vital air. 9. In the mutual action which takes place between the quantities of air and blood which come in contact in twenty-four hours, the air loses three hundred and twenty-eight ounces of oxygen, and the blood, ten ounces of carbon."

Such are the wonderful processes in reference to respiration as dependent on the atmosphere. When we reflect that a stratum of blood, several hundred feet in surface, is exposed to a stratum of air still more extensive, and all compressed within the compass of a few inches, we cannot but be filled with admiration at the Divine wisdom displayed in this and many other functions of the human system, which so far surpass all the contrivances of genius, science, and art. In every part of the workmanship of the Almighty, even the most minute, we perceive the impress of infinite goodness and intelligence, demonstrating that He who formed the human frame and the surrounding elements is "wonderful in counsel, and excellent in working." Not only are terrestrial animals and the fowls of heaven dependent for existence on

the atmosphere, but even the fishes of the sea cannot subsist for any length of time without its invigorating influence. Every fish is furnished with an air-bladder, by which it is enabled to rise in the water, or sink into it at pleasure. The lungs of fishes are their gills; these consist of filaments, arranged somewhat like the feathers of a quill; they are found to be covered with minute processes, crowded close together, and on which are observed, by the microscope, millions of capillary blood-vessels spread, like a net-work, over the whole surface. It is through the thin coats of these vessels that the air acts upon the blood they contain. When a fish is taken out of the water, the reason it cannot breathe is, that these filaments collapse, and adhere together in a mass, and the air cannot separate them. If the air be extracted from the water in which fishes swim, or if they have no free communication with the air, they are soon deprived of existence.

5. The atmosphere is the medium in which the process of evaporation is carried on, and in which clouds, rain, and dew are produced. By the heat of the sun and other causes, an immense portion of matter is daily carried up into the atmosphere in the form of vapour, in which state it occupies a space 1400 times greater than in its ordinary liquid state. It has been found, by experiment, that an acre of ground, in the course of twelve hours of a summer's day, dispersed into the air, by evaporation, 16,000 gallons of water. Every hour there are exhaled in this way, from the surface of the ocean, many millions of gallons, and every year about 40,000 cubical miles of water. This vast body of water, sometimes in an invisible form, and sometimes in the shape of clouds, is carried by the winds over the different regions of sea and land. A part of this water is condensed into thick clouds, and falls down in rains on the continents and islands, to fertilize the soil; a part descends on the seas and oceans; and another part supplies the sources of the rivers, by which it is again returned to the ocean, whence it was chiefly derived. This continued circulation of vapour through the atmospherical regions, is one of the most important processes in the system of nature connected with our globe. By means of it, the Creator displays his wisdom and unbounded benevolence, in conveying fertility to the different climates of the earth, and thus supplying nourishment and comfort to man and to all the inferior orders of animated existence. But it is evident that, without the ministration of the atmosphere, these beneficent operations could not be carried on, and the earth would be left to parch under the rays of the sun, till it were trans-

formed into a bleak and barren desert. It is owing to this process of evaporation that our clothes and linens are dried, after having been washed, and that our roads are rendered clean for walking upon, after having been drenched with heavy showers of rain, or covered with deep snows; without the operation of which, a thousand discomforts and inconveniences would be felt in all the scenes of domestic life, and the operations of art; and this world would cease to be an abode of happiness and enjoyment.

6. The density of the atmosphere gives buoyancy to the clouds, and enables the feathered songsters to transport themselves with ease from one part of the earth to another. If the air near the earth were much rarer than it is, the clouds would sink to the surface of the earth, involve the world in a dismal gloom, and intercept our views of the beauties of the terrestrial landscape, and of the glories of the midnight sky. The birds would be unable to perch on the tops of lofty trees, or to wing their flight from shore to shore. As a proof of this, Mr. Robertson, who ascended in a balloon from St. Petersburgh, in 1804, informs us that he took along with him some live pigeons, and, at different heights, gave liberty to these birds, who seemed very unwilling to accept of it. The poor animals were so terrified with their situation, that they clung to the boat of the balloon till they were forced from it, when it appeared their fears were not groundless; for their wings were nearly useless, from the rarity of the air, and they fell towards the earth with great rapidity. The second struggled with eagerness to regain the balloon, but in vain; and the third, thrown out at the greatest elevation, fell towards the earth like a stone, so that he supposed it did not reach the earth alive. This was evidently owing to the extreme rarity of the air in those upper regions to which the balloon ascended.

7. The atmosphere is the region in which winds are produced, which perform many important offices in the economy of our globe. Winds are nothing else than portions of air in motion; and although they sometimes excite our fears by the violence of their rage, and scatter destruction by sea and land; yet their agency, on the whole, is highly beneficial, and even essentially necessary to mankind. They purify the air by keeping it in perpetual motion; they disperse the noxious vapours that are continually rising from stagnant marshes and common sewers; they sweep the chambers of the atmosphere; they ventilate the streets of populous cities, and prevent the accumulation of those noxious effluvia which would

produce pestilence and death; they scatter the seeds of various plants over every region; they fan the air under the scorching heats of summer, and diffuse refreshment over a fainting world; they make our millstones revolve as nimbly as the wheels of a chariot, and they serve as wings to our floating edifices, to impel them across the ocean, and to bring them back laden with the treasures of distant lands.

Were the agitation to cease which the wind produces, all nature would be thrown into the utmost confusion. Navigation to distant shores, as hitherto most generally conducted, would be at a stand, and ships would be arrested in the midst of the ocean. The vapours exhaled by the heat of the sun would remain for ever fixed over those particular spots whence they arose, instead of being dispersed, as they now are, over every region. One part of the world, by the interposition of stationary clouds, would be for ever deprived of the direct influence of the solar rays, and of the light of the stars; while, in another part, the soil would be parched, and the grass burned up, for want of a veil of clouds to modify the heat of the sun. One region would be scorched for want of moisture, and another drenched with excessive rains. The putrid exhalations of dunghills, marshes, and populous cities, would remain perpetually suspended around the places whence they arose, and produce diseases and pestilence, which would sweep the inhabitants of the earth in rapid succession to the grave. But in the existing economy of nature, all such disastrous effects are prevented by the agency of the winds, which distribute the clouds in due proportion over every land, and serve as ventilators to all the regions of the atmosphere.

8. Air is the vehicle of smells, by the transportation of which we become acquainted with the good or bad qualities of the food which is set before us, and are warned against sitting in places that are damp and dangerous, or entering houses that are unwholesome or infectious. By means of the air, the odoriferous effluvia of plants and flowers are diffused over the fields, and conveyed to the nostrils, to increase our delightful sensations, when wandering among the scenes of nature.

9. Air is likewise the medium of sounds. In consequence of its elasticity and undulating motion, it conveys to us knowledge and enjoyment of different kinds, which cannot be conveyed to the organs of sight, of taste, or of smell. A few strokes on a large bell will, in the course of a few seconds, by the undulation of the atmosphere, reach the ears of a

hundred thousand men, and convey intimations either of joy or terror. The sounds produced by the undulations of the air may be considered as so many couriers running backwards and forwards, and in every direction, to warn us of danger, to inspire us with joy, and to communicate various delightful sensations. When we walk along the road, musing, and unapprehensive of danger, a mail-coach may be whirling on in its rapid career, and just at our heels, ready to roll over us; but the air, like a watchful friend, despatches a courier from a considerable distance to warn us that danger is approaching, and to remove to the path of safety. While we walk along the streets of London, and other cities, we are continually in danger of cabs, coaches, drays, and other vehicles, rolling upon us; and were it not that the air, by its undulations, gives us timely notice of their approach, the accidents from this cause which occasionally occur, would be much more numerous than they now are. To this property of the air, we owe all the advantages we derive from hearing sermons and lectures, and all the pleasures we enjoy from friendly and instructive conversation. By means of the tongue and the lips we form articulate sounds, which, by the previous consent of mankind, become the signs of certain ideas; these sounds are conveyed to the ears of our friends, and inform them of the thoughts and ideas that were previously passing through our minds, and their understandings and hearts become impressed with the same sentiments. Without the ministration of the atmosphere in such cases, all would be sullen and unmeaning listlessness and silence, as in the intercourse of the deaf and dumb. So that the air may be considered as the cement of society—the medium of communication between one mind and another, and the interpreter of the thoughts and purposes of mankind.

To the same cause, we are indebted for all the pleasures and harmonies of music. Music is one of the purest and most refined of our sensitive pleasures. It possesses the power of charming our ears, soothing our passions, and affecting our hearts; it dissipates the gloom of melancholy, animates the vital spirits, and gives sublimity to our thoughts and sentiments. When a lady tunes her melodious voice, or touches with her fingers the keys of the piano-forte, or the strings of the lyre, the air distributes every musical variation and every note, with the utmost precision. It conveys its message with the greatest impartiality to the ear of every listener. Though many instruments may be employed, and a thousand persons be present, and placed in every direction, it distributes the har-

mony alike to every ear. It keeps the most exact time—it conveys the slightest inflections of the voice, and the smallest variation of a tone. It runs through the whole compass of music, swells the sounds, and makes them even thunder in our ears. The next moment, it makes them flutter and melt into dying strains. After this, it swells the notes again, and sinks them in their turns. Thus it expresses, in the most lovely manner, every passion and emotion of the soul, and charms every heart with its persuasive sounds.

That all the effects now stated are owing to the ministration of the atmosphere, is proved by one decisive experiment. Place a small bell under the receiver of an air-pump; let it be rung, and the sound will be heard at a considerable distance. Exhaust the air from the receiver, and the sound can scarcely be heard by the nicest ear. Even in places where the air is not excluded, but only highly rarefied, as in the higher regions of the atmosphere, sounds are scarcely heard. Fredlichius, a gentleman of Hungary, informs us, that when he was on one of the loftiest tops of the Carpathian mountains, he fired a pistol, which at first made no greater noise than if he had only broken a stick or a staff; but after a little time there was a murmuring for a while which filled the valleys and woods below. Descending to the lower valleys and the rugged rocks, he fired again, which made a dreadful sound, as if great guns had been discharged, and as if the whole mountain had begun to tumble about his ears. The sound lasted for half a quarter of an hour, till it had reached the most secret caverns, where the sound was enlarged and reflected back in every direction. These facts show that the elasticity of the air, which is always greatest where the air is densest, is essential to the propagation of sound.

10. The atmosphere is the cause of that splendour and universal light around us, which lays open to our view the landscape of the world. Were this atmosphere destroyed, we might see the sun without enjoying the light and brilliancy of day. That luminary would, indeed, strike our eyes with a vivid brightness when we turned round to behold his flaming orb; but it would appear only as a blazing fire during night in a spacious plain, where all is gloom and darkness around. It would suddenly burst on our view in the eastern horizon, in the morning, and would not change its aspect in the least, during its course through the heavens, till it suddenly disappeared in the western sky. The objects immediately around us would be partially visible; but

the rays of the sun which fell on distant objects would be for ever lost in the expanse of the heavens; and when we turned our back to the sun, nothing would present itself, but an abyss of darkness, and the whole horizon involved in a dismal gloom. The number of objects in the heavens would, indeed, be augmented, for the stars would shine through a canopy as black as ebony, even when the sun was above the horizon; but all the gay colouring of the terrestrial landscape, which now delights the eye and the imagination, would be for ever veiled from the inhabitants of the world. In such a state of things, it would be always night; and the difference between such a night and that which we now enjoy, would be, that the celestial orbs, instead of being grounded on a beautiful azure sky, would appear on a black canopy, like so many white points on a dismal mourning carpet.

But the Almighty, whose arrangements have all a respect to the happiness of his creatures, has enveloped our globe with an atmosphere, and has endowed it with a capacity of reflecting and refracting the rays of light in all directions. This atmosphere, too, is charged with innumerable myriads of watery particles, exhaled by evaporation from every region of the sea and land. In the serenest days of summer, when no clouds nor vapours are to be seen, these rarefied particles of water, which are imperceptible to the keenest eye, fill the whole sphere of the atmosphere around us, both above and below the region of the clouds. It is among these rarefied waters in the higher regions of the air that the rays of light reflected from the surface of the land meet, and are again reflected in every direction to the earth; and hence is produced that beautiful azure colour which distinguishes the aspect of the heavens. This azure is sometimes lighter, according to the quantity of the rays which enter the atmosphere, and sometimes darker, when the absence of the twilight heightens the blue of the celestial concave, by means of that black and void space which lies beyond the limits of the atmosphere. In corroboration of these remarks, it may be noticed, that the higher we ascend above the surface of the earth, the darker does the sky appear. And hence all travellers affirm, that, on the tops of lofty mountains, it sometimes appears as black as ebony, which causes the milky way to appear like a pure flame shot across the heavens, and the stars to shine with a greater brightness, and to appear far more numerous than in the plains below.

11. The atmosphere is the cause of the morning and evening twilight. We all know that the day is gradually ushered

in after the darkness of the night. More than an hour before the rising of the sun, in this part of the world, a streak of light appears in the eastern horizon. This light increases in brilliancy every moment—the landscape of the earth, which had been previously covered with a mantle of blackness, appears gradually to emerge from an abyss of darkness, like the light at the first creation—the circle of the horizon becomes inflamed with a bright vermilion—the mountain tops are tinged with purple; and at length appears the most beautiful and sublime object in nature, the sun rising in his might and glory. And, when this luminary has described the circuit of the heavens, and passed the verge of the western horizon, darkness does not come on instantaneously, but by slow and imperceptible degrees, so as to warn us to prepare for its approach. The season of twilight, particularly that of a summer evening, is perhaps one of the most agreeable and interesting periods of the day. How many delightful walks and excursions—how many cheerful and solemn musings—how many endearing intercourses of love and friendship does it recall to our recollection, when we strolled along the solitary walks, or reclined in the bower of friendship, till the rising moon and the twinkling stars called us to our nightly repose!

Now, all such pleasures and advantages, derived from the twilight, are owing to the agency of the atmosphere. When the sun approaches in the morning within eighteen degrees of the horizon, his rays strike obliquely on the higher parts of the atmosphere, and, instead of passing directly forward, they are refracted, or bent a little downwards, and thus descend by inflection to the earth. In this way we reap the benefit of those rays which would otherwise have been totally lost, and enjoy the light of day for a considerable time before the sun reaches the horizon. It is owing to the same cause that the sun is visible several minutes before he is actually above the horizon in the morning, and after his setting in the evening. This increases the length of every day, about $6\frac{1}{2}$ minutes at an average, which amounts to $3\frac{1}{2}$ equinoctial days in a year, and nearly a whole year's sunshine in the course of a century. And, if we reckon an hour and a half of twilight in the morning and as much in the evening, at an average, through the different seasons, we have more than ninety equinoctial days of twilight throughout the year. This is a circumstance of the utmost importance to those who inhabit the polar regions; in consequence of which, the inhabitants of Nova Zembla and of Greenland enjoy the direct light of the sun for

thirty-two days while he is under the horizon, besides the long twilight which precedes his rising, and continues after his descent below the horizon. But what would be the consequences if we had no twilight? Not only should we be deprived of the advantages now stated, but subjected to many inconveniences and dangers. Should the day break in upon us all at once in meridian brightness, immediately after the dark shades of night, our eyes would be dazzled, and in danger of being blinded by its excessive splendour. Should the night rush on in the same precipitate manner, and hurry us in a moment from the splendours of day to the horrors of midnight, it would strike the living world with amazement. The traveller would be arrested in the midst of his journey, and bewildered with terror; and if the sky were then covered with clouds, the darkness would be so thick and black, that not the least glimmering ray would strike across the universal gloom, nor a single object be perceived, even within the distance of a foot. Man would then appear as if he were placed without an object near him in the midst of infinite space—

> ——"Dark as was chaos, ere the infant sun
> Was rolled together, or had tried his beams
> Athwart the gloom profound."

These arrangements, then, by which light is reflected over the face of nature, and twilight is produced, evidently show the wisdom and intelligence of the Almighty Creator, and his benevolent regards to his sensitive and intelligent offspring. A few small bubbles of air and water appear very insignificant to the eye of man. But in the hand of the Almighty they work wonders of love and beneficence. He has distributed them over our heads in every direction with so much caution and skill, in order that the light of his sun and his stars might not be rendered useless to the world. With these invisible particles of water and air, he enriches and embellishes whatever he pleases; and in his hands they become an inexhaustible source of glory and happiness. From these insignificant atoms, he fetches the brightness of the aurora, and draws forth those twilights which lengthen our days, and prepare our eyes for receiving the brightness of the meridian sun. From these he produces the splendour of day, which the sun itself could never procure us. He makes them contribute to the preservation of that heat which nourishes the vegetable kingdom, and which is essential to the comfort of "every thing that lives." Of them he has formed that magnificent arch which surrounds us on all sides, which enchants the eye of every beholder, and forms the canopy of our terres-

trial habitation; for it is the light reflected from the air, and the innumerable particles of vapour it contains, which produces that beautiful azure which adorns the vault of heaven. This azure canopy the Creator might have painted with a darker hue, or even made it entirely black. But black is a sad and dismal colour, which would have thrown a melancholy gloom over the face of nature. A deep red would have been almost as disagreeable and hurtful to the sight; a white colour, by its excessive glare, would have been oppressive to every eye, and would have prevented the light of the planets and stars from being distinguished. A yellow would not have been quite so unsuitable; but this colour was reserved for the aurora which adorns the sky before the rising of the sun. Besides, a whole arch of a yellow colour would not have presented a sufficient contrast to the light of the celestial luminaries. The green, which is a pleasing colour to the eye, would have formed a better ground for the light of the stars; but it is with this lovely colour that the Almighty has adorned the surface of our earthly abode, and has spread it as a carpet under our feet; and it was necessary that there should be a contrast between the colour of the earth and of the sky, in order to complete the beauty and the magnificence of the scene of nature. The blue is, on the whole, a mild and pleasant colour, without gloom or sadness in it; and while it forms a contrast to the verdure of the fields, it has the additional merit of forming a proper ground on which luminous bodies may be seen, and thus heightens the lustre and beauty of the stars.

In such admirable arrangements we cannot fail to perceive the marks of intelligence and skill, in causing the assemblage of invisible atoms to produce so many sublime and beneficent effects; and we must be void of gratitude, if we do not recognise the hand of Divine goodness in adorning our habitation with so many beautiful contrasts, and rendering every scene of nature subservient to our convenience and delight.

12. The transparency of the atmosphere is not the least of its advantages. It is not, indeed, perfectly transparent, otherwise it would not reflect the blue colour of the sky, nor would the distant mountains appear bedimmed and tinged with purple. But it has such a degree of transparency, that every object on the terrestrial landscape, within a reasonable distance, can be distinctly perceived. Even objects at the distance of a hundred and fifty miles, are visible through the air; and the telescope, though it magnifies the aërial particles, can make objects, at the distance of twenty miles, appear as if they were

placed at the distance of three hundred yards. Were the air tinged with the least degree of yellow, red, or green, it would give the same colour to every other object, just as a stained glass makes every object seen through it appear of the same colour as itself. Were its particles much larger, and more opaque than they now are, so as to become perceptible to the eye, we should never obtain a distinct view of any other object. We should then see the air and the exhalations rising from the surface of the earth continually before us, like the particles of dust in a darkened chamber, when the rays of the sun are admitted through a small hole.

But the Almighty, by rendering the air invisible, has enabled us, in the first place, to take an extensive and delightful view of his wonderful operations in heaven and earth, and of all the objects which immediately surround us—and, in the next place, has concealed from our eyes those objects which would have excited disagreeable sensations, and even disgust. If the air, like all other bodies, were an object of sight, the exhalations from the earth and waters would be much more easily discovered The smoke of our chimneys, still remaining visible as it ascended, would disfigure the rich landscape of the world, and obscure the canopy of heaven. We should perceive all those gross humours which an incessant perspiration drives out of the bodies of all animals, and all the filthy exhalations that rise from kitchens, dunghills, stagnant marshes, streets, and common sewers. We should be apt to imagine our situation both unsafe and contagious, unless we fled into deserts and mountains, to avoid those incessant annoyances which would be the unavoidable result of such a visibility of the air and its exhalations. At the same time, lest these vapours should prove injurious to us through their invisibility, the good providence of God has forewarned us of such danger, by imparting to us the sense of smell, and has also appointed the winds to disperse such nuisances, to carry them aloft, and to serve as the ventilator of the atmosphere ; for, by the sense of smell, we are enabled to perceive when we are within the range of pestilential effluvia ; and the winds seldom permit the air to remain in a stagnant state, provided our habitations are so arranged as to be within the sphere of their influence.

If we wish to feel grateful to the Supreme Disposer of the universe for the blessings of that world in which he has placed us, it is requisite that we should frequently fix our attention on such circumstances as those now stated. We pass from one day to another, and frequently from one period of

human life to another, without reflecting on those admirable contrivances which appear in every surrounding object, by which our comforts are secured, and the universe rendered a spectacle of beauty and grandeur. Because we have never yet contemplated a world in confusion and ruins, we are apt to imagine that the arrangements around us could not be otherwise than they presently are. But, were that Being who created the atmosphere to make only a very slight alteration in its constitution—were he just to alter two apparently insignificant circumstances—were he to deprive it of its refractive and reflective powers—and were he to render it visible by tinging it with any colour, all other things remaining as they now are—immediately the scene of nature would be divested of all its beauty and magnificence—and this earth, which now cheers so many millions of animated beings with its comforts and embellishments, would be transformed into a scene of misery, an abode of darkness and desolation.

13. Were the atmosphere capable of being frozen, or congealed into a solid body, the most disastrous consequences would immediately ensue. All other fluids with which we are acquainted are subject to congelation. Even spirits of wine, which long resist the influence of the cold, and are, therefore, used in our thermometers, have been converted into a solid mass, by the cold of northern regions; and quicksilver, which is naturally a fluid substance, has been converted by cold into a compact body, capable of being hammered like a piece of lead. Nay, even some of the gases, or aërial fluids, show a disposition to congeal by a reduction of temperature. The oxygenized muriatic-acid gas becomes concrete, and forms into crystals, at a temperature of near to that at which water freezes. All the gaseous substances, when they have lost their elasticity, by forming certain combinations, are disposed to assume the solid state, if the temperature allow it. Ammoniacal gas, and carbonic-acid gas become solid, as soon as they enter into combination; and hydrogen gas, the most subtle of the ponderable elastic fluids, forms, along with oxygen, that very water which is afterwards congealed into ice. What is the reason, then, that the atmospheric air which we every moment breathe, is not subject to congelation? We know no other reason than the will of the Creator. Were we thoroughly acquainted with every particular respecting the nature of the gases of which it is composed, and the mode of their combination, we might, perhaps, discover the physical cause of this singular property; but still, we should ultimately have to refer it to the Divine pur-

pose and will that such a cause existed. We know that the vapours which are suspended in the higher regions of the atmosphere, are frequently congealed into hailstones of considerable size, and were any large portions of the air around us to be congealed in a similar manner, it is easy to foresee what disastrous effects would quickly be produced; and were the whole atmosphere to be frozen into a solid body, destruction would inevitably seize upon all the tribes of the living world, and the beautiful face of nature we now behold, would be transformed into a chaos.

Such is the intimate connection that subsists between every part of the system of nature, and such is the exquisite mechanism with which all its parts are constructed and arranged, that if a single wheel or pinion of this vast machine were either wanting or deranged, the whole system would soon be dissolved, and fall into ruins. But that Almighty Being who sits on the throne of the universe, presides over all its subordinate movements, preserves every element in its respective station, and directs the apparently jarring principles of nature to accomplish his wise and benevolent designs.

In fine, we may just further remark, that man has acquired a certain degree of sovereignty over the atmosphere, by which he renders it subservient to his comforts, and to the execution of his designs. He causes it to sigh in the pipe, to complain in the flute, to thunder in the trumpet and the gong, and to utter a thousand melodious strains in the pianoforte and the organ. He causes it to announce tidings of joy or sorrow. He forces it to grind his corn, to blow his furnace, to winnow his grain, to raise water from the deepest pits, and to extinguish the flames when his buildings are on fire. He compels it to act as a prime mover in an endless variety of machinery, and, by its agency, in combination with other powers, ten thousands of wheels and pinions are daily set in motion—power-looms are weaving fabrics of various descriptions—spinning-jennies are set in action, steam-vessels impelled along rivers, and across oceans—and railway trains carried forward in every direction with the most rapid motions. He yokes it to his ships, and compels it to expand the sails, and to waft him across the billows of the ocean to the remotest shores. And, in short, it is on the wings of the atmosphere that he raises himself, with his balloons, above the mountain-tops, looks down from on high on the dusky earth, and ranges at large through the region of the clouds.

Thus, a few of the beneficial effects produced by the atmosphere in the system of nature, have been briefly stated. Its

influence is essential to the germination and growth of plants, to the preservation of water in a state of fluidity, to the existence of fire and flame, to the respiration of all kinds of animals, to the process of evaporation, and the production of rain and dew; to support the clouds, and to give buoyancy to the feathered tribes. It is the region of winds—the vehicle of smells—the medium of sounds, and the source of all the pleasures we derive from the harmonies of music; it is the cause of that universal light and splendour which are diffused around us, and of the advantages we derive from the morning and evening twilight; and all these advantages are more fully secured by the transparency of its particles, and by its being rendered incapable of being congealed into a solid body.

What, then, would be the consequences were the earth to be divested of its atmosphere? Were the hand of Omnipotence to detach this body of air from our globe, and could we suppose living beings at the same time to exist, the landscape of the earth would be disrobed of all its vegetable beauties, and not a plant nor flower would be seen over the whole face of nature; the springs and rivers would cease to flow, even the waters of the mighty deep would be dried up, and its lowest caverns be exposed to view, like frightful and hideous deserts. No fire nor heat would cheer the abodes of man, either by day or by night, no rains nor dews would refresh the fields, no gentle zephyrs would blow, nor aromatic perfumes be wafted from blooming flowers. The birds would no longer wing their flight on high, nor would their warblings be heard among the groves. No sound whatever would be heard throughout the whole expanse of nature, universal silence would reign undisturbed over the world, and the delights of music be for ever unknown. The morning would no longer be ushered in by the dawn, nor the day protracted by the evening twilight. All would be gloom and obscurity by day, except in that quarter of the heavens where the sun appeared, and no artificial light nor flame could be procured to cheer the darkness of the night. The whole surface of the globe would present one wide prospect of barrenness and desolation, without a single object of beauty to relieve the horrors of the scene; and this earth, which now presents to the beholder so many objects of sublimity and beauty, would appear as if it had sunk into the primitive chaos whence it arose. But, as we are certain that, according to the present economy of the animal system, no living creatures could exist in such a state of things, it would be an inevitable consequence of the annihilation of the atmosphere, that all the my-

riads of living beings which now people the waters and the earth, would sink into remediless destruction, and the great globe we inhabit be transformed into one immense sepulchre, without enjoyment, motion, or life.

If, therefore, the Creator had not a regard to the happiness of his sensitive and intelligent offspring—or, if he wished to transform this globe into an abode of darkness and a scene of misery, he has only to support the functions of animal life on a new principle, and then to sweep from the earth the atmosphere with which it is now environed, and the dismal catastrophe is at once accomplished. Such a consideration shows us the propriety and the emphasis of the language of Inspiration, "In Him we live, and move, and have our being"—"In his hand is the soul of every living thing, and the breath of all mankind." But since we are assured that "the Lord is good to all: and his tender mercies are over all his works," and as we find no arrangement in the system of the universe whose ultimate object is to produce pain or misery to any sensitive being, we have no fear that such a catastrophe will ever be permitted to take place. At the same time, we know not what the great ends of his moral government may incline the Deity to perform. We know that, at one period, the system of nature connected with this globe was disarranged on account of the wickedness of its inhabitants, and a deluge of waters overwhelmed all the abodes of men. This catastrophe changed the aspect of the earth and atmosphere, and produced convulsions which shook the foundations of the earth, and disrupted its solid strata; the vestiges of which are still visible in every land, and form some of the subjects of scientific investigation. And, therefore, were the inhabitants of the world ever again to rise to the same pitch of wickedness as they did before the flood, we know not but the Almighty, instead of covering the earth with an abyss of water, might detach from it the surrounding atmosphere, and leave its inhabitants to the effect of such an awful catastrophe.

We learn from Revelation, that a period is approaching, "when the elements shall melt with fervent heat, the earth also, and the works that are therein shall be burned up." In the hand of Him who sits on the throne of the universe, the atmosphere is fitted to become the means of producing this tremendous event. The atmosphere, as formerly stated, consists chiefly of two fluids, or gases, of very opposite qualities; one of these, namely oxygen gas, is the principle of combustion, and forms about one-fifth part of atmospheric air; the other, namely nitrogen, instantly extinguishes every species

of fire or flame. Were the nitrogen, then, which forms four-fifths of the atmosphere, to be swept away, and the oxygen left to exert its native energies, all the combustible substances on the face of the earth would instantly take fire, nay, the hardest stones, the most solid rocks, and even water itself, would blaze under its force with such energy as to carry destruction throughout the expanse of nature. Such are the elementary principles in the hand and under the superintendence of the Almighty, which are ready at his command to bring into effect all the events, changes, and revolutions, in relation to our world, which are predicted in the word of Divine Revelation.

CHAPTER VIII.

THE WISDOM AND BENEVOLENCE OF THE CREATOR, AS DISPLAYED IN THE CONSTITUTION OF THE ATMOSPHERE.

As this topic has been partially alluded to in the preceding chapter, only two or three additional illustrations may now be given.

1. The wisdom and goodness of God are manifest, in the proportion which subsists between the different gases of which the atmosphere is composed. Were the oxygen less in quantity than it now is—were it, for example, in the proportion of fifteen to eighty-five, in a hundred parts of nitrogen, instead of twenty-one to seventy-nine, fire would lose its strength, candles would not diffuse a sufficient light, plants would wither, and animals could not breathe without the utmost difficulty and pain. On the other hand, were the nitrogen diminished, and the oxygen greatly increased, the least spark would set combustible bodies in a flame, and, in a few moments, they would be entirely consumed. Candles would be wasted in a few minutes after they were lighted, and would serve no other purpose than to dazzle our eyes with a transient blaze. Were a few houses in a large city set on fire, such would be the rapidity with which the flames would spread on every side, that in a few hours, or even minutes, the whole city would be wrapped in one wide and unquenchable blaze, and no human art could arrest the progress of the destructive conflagration. In such atmospheric air, iron would be calcined, instead of acquiring from the fire that soft-

ness necessary for forming it into various instruments; it would accelerate to a dangerous degree the circulation of the fluids in animal bodies, and produce a degree of heat through the influence of which they would rapidly waste and decay. We know by experience that nitric oxyde, which consists of forty-four parts of nitrogen and fifty-six of oxygen, produces instant suffocation in all animals that attempt to breathe it. We also know that the nitric acid, one of the most corrosive substances, is composed of seventy-five parts oxygen and twenty-five parts nitrogen, which are only different proportions of the substances in atmospheric air; so that were the atmosphere composed of the same proportion of ingredients, our breathing it might produce the same effect as if we were to swallow a pint of aquafortis, or nitrous acid, which we all know would produce our immediate destruction. Can we, then, be at a loss to perceive, in the adjustment of the gases which compose our atmosphere, the wisdom and benevolence of the Deity; and, at the same time, the infinite comprehension of the Divine Mind, in foreseeing all the effects that would be produced by the different combinations of these gases, and in selecting that particular combination for the atmosphere which is precisely adapted to the existence and the comfort of living beings?

2. The Divine wisdom and goodness are no less conspicuous in determining the relative specific gravity of these gases. The oxygen gas is found to be a little heavier than common air, and the nitrogen a little lighter, which enables it to rise to the higher regions of the atmosphere. In respiration (or breathing) there are four stages or periods:—1. Inspiration, or drawing in the air.—2. A pause when the lungs are filled.—3. Expiration, or breathing out the air from the lungs;—and 4. A pause when the lungs are emptied. In breathing, the air which is evolved from the lungs at every expiration, consists chiefly of nitrogen, (and a small portion of carbonic-acid gas,) which is entirely unfit to be breathed again, and therefore, by its levity, rises above our heads before the next inspiration. The pause which takes place between every inspiration is evidently intended to allow time for the nitrogen gas which is thrown out of the lungs to rise in the air, in order that a fresh portion of the atmosphere may be taken in, and that the same air may not be breathed again. During that remarkable interval, there is time left for the noxious fluids to separate, the nitrogen to ascend while the carbonic-acid gas preponderates, leaving a space between for a fresh current of pure atmospheric air to rush

into the lungs. But what would be the consequence if nitrogen gas, instead of being a little lighter, had been a slight degree heavier than common air, or of the same specific gravity? Then we should not only have been obliged to breathe a portion of it again at every inspiration, but the vast quantity of it thrown off by the respiration of men and other animals would have perpetually occupied the lower regions of the atmosphere; and especially in our chambers it would have accumulated to such a degree as to have produced diseases, pestilence and death, in rapid succession. But, being a little lighter than the surrounding atmosphere, it flies upwards, and we never breathe it again till it has entered into new and salutary combinations. Such is the benevolent skill which the great Author of nature has displayed for the preservation and comfort of the human family and of every species of animated existence.

3. The wisdom of the Creator is displayed in the process for supplying the waste of oxygen, and promoting the renovation of the atmosphere. The quantity of carbonic acid which is daily formed, by combustion and the respiration of animals, is so great, that it must have rapidly increased to a most dangerous extent, had not the Almighty provided means for its being as rapidly decomposed. It is well known that whenever atmospheric air becomes charged with one-tenth of this gas, it is unfit for promoting combustion, and is fatal to most animals that breathe it. Hydrogen too, and carburetted hydrogen gas, are perpetually evolved at the surface of the earth from various sources, particularly from marshes, dunghills, and stagnant pools; and these are likewise prejudicial, and even destructive, to the animal creation. On the other hand, oxygen gas, which is the support of fire and animal life, is continually wasted by the various processes of combustion, as in the case of furnaces, burning candles, and domestic fires, and by the breathing of all animals. How, then, has the all-wise Creator contrived to supply this waste, and to protect the inhabitants of the world from the baneful effects of the other gases with which the atmosphere is contaminated? The process appears to be this:—Vegetables are so constituted that carbon and hydrogen are the necessary food of plants, and are conducive to the support of vegetable life. Their vegetating organs seize the carbonic-acid gas that comes within their reach, and while they appropriate the carbon to themselves, the oxygen is thrown off to renovate the atmosphere, by its union with the nitrogen ejected by animal respiration. The leaves of trees,

shrubs, and other vegetables, give out, during the day, a large portion of oxygen gas, which unites with the surrounding air, keeps up the equilibrium of the gases, and preserves the salubrity of the atmosphere; for it is found by experience that the air in every region, in the most crowded cities, as well as in the open fields, contains the same quantity of oxygen gas. Thus it appears, that what is noxious to man is rendered beneficial to the vegetable tribes, and the oxygen of which they do not stand in need, is separated by them, in its utmost purity, for the use of man. The wisdom, the simplicity, and the beneficence of this arrangement, cannot fail to produce conviction in every reflecting mind, that the laws of nature are not to be referred to blind chance, but to unerring intelligence combined with boundless beneficence. In every breath we draw, we may perceive, if we reflect on the above stated arrangements, that we are every moment indebted to an all-wise and almighty Being, in whom we live and move, for the continuance of our existence and for every comfort we possess, and therefore praise, adoration, and thanksgivings, are due to him from all the ranks of his intelligent offspring.

The department of the subject already treated, may now be concluded with a reflection or two, founded on the statements previously made

1. From the invisibility of the atmosphere, and its numerous and important effects in the system of nature, we may learn the folly of denying the reality of a future and invisible state of existence, because the objects connected with that state are not perceptible by our corporeal senses. Who could have imagined, previously to modern discoveries, that all the functions of the vegetable kingdom, and all the comforts enjoyed by animated beings, are dependent upon the operation of a few invisible fluids, and that all the beauties of this lower creation are owing to the composition and decomposition, in a thousand different ways, of those gaseous substances whose operations are imperceptible to the keenest eye? And yet, the researches of modern chemistry have proved this fact to a demonstration, and shown us that every breath we draw, every pleasing sensation we feel, every portion of food we eat, every particle of heat that warms our apartments, every ray of artificial light that illuminates our streets and habitations, and every musical sound that enchants our ears, are owing to the unremitting motion and energy of invisible sub-

stances. And shall we, then, assert that the invisible principle of mind is not in existence or in action beyond the limits of this diurnal sphere, because its operation in that state lies beyond the range of our senses? We behold multitudes of rational beings daily departing from the living world; their organical frames crumbling into the dust, and the intellectual principle which animated them disappearing from mortal view. But we have no more reason to doubt that it is existing and operating in another sphere, than we have to doubt of the incessant energy of the invisible gases in giving life and beauty to sublunary nature. The disembodied spirits of men, whether existing in a pure ethereal form, or invested with fine material vehicles, may be employed in active services, and in sublime contemplations and investigations, of which we can at present form no adequate conception. We may, on the same grounds, form a conception of spirits suffering pains, anxieties, sorrows, and miseries, of different kinds, from a retrospective view of their former feelings, affections, and conduct, even when separated from those material organs with which they were formerly connected.

With regard to the great objects of religion, many of them lie beyond the range of our corporeal vision, as some of the agents employed in certain chemical processes elude our senses. Faith is described to be "the confident expectation of things hoped for, and the conviction of things which are not seen."* It substantiates and realizes those objects which are invisible to the eye of sense, or which lie far beyond its present range of view. Hence we are told that, in the present world, we should "walk by faith, not by sight." The objects connected with a future world are real, although they are placed at such a distance as not to be cognizable by our present visual organs. They are not all merely of a spiritual nature, they are also connected with material objects; but, between our sensitive organs and such objects, immeasurable regions of space intervene. The glorified body of the Redeemer of mankind is a material substance and an object of sense, and it inhabits a region somewhere within the bounds of the material creation, but its distance from the sphere in which we now reside removes it from our view; and we want that vigour and energy of our corporeal organs which the martyr Stephen seems to have enjoyed, when the heavens were opened, and "he saw the glory of God, and Jesus standing on the right hand of God."

* Dodderidge's translation of Heb. xi. 1.

In certain pools of water, animalcules are found, whose bodies, when magnified a hundred thousand times their natural size, are visible only as so many moving points. A considerable portion of the watery element on our globe is filled with such invisible inhabitants, which have never been perceived by the millionth part of mankind. In this and similar instances, we have an invisible world of animated beings existing around us, but no one calls in question their existence because they can only be observed by powerful microscopes, and are not perceptible by the majority of mankind. In short, the Divine Being pervades every part of space with his essence, and is intimately present with every one of his creatures, yet remains for ever invisible to mortal eyes. But, on this ground, no one but an atheist ever calls in question his existence. In like manner, the invisibility of the objects connected with a future world ought to form no ground of doubt respecting the certainty and reality of their existence.

2. We may learn what ought to be our great object in the study of the sciences, and in the investigation of the phenomena of nature.

Some persons are disposed to consider science and natural history merely as genteel studies; others apply their minds to such subjects with the view of bearing a part in the conferences of men of learning. Some, again, prosecute such pursuits for the purpose of making collections of scarce and valuable curiosities, and of displaying a degree of knowledge and taste superior to those of their neighbours; and the greater part of mankind consider such studies as only an amusement, or a relaxation of mind from the fatigues of their daily avocations. But the study of nature and of science is highly dishonoured by such grovelling and contracted views. The prospect of the universe was exposed to our view for more noble and exalted purposes—to make us wiser and better men, to expand our views of the perfections of our Creator, and to inspire us with a grateful sense of all the blessings we daily receive from his bountiful hand.

There are two great objects which we ought always to keep in view in our investigations of the laws of nature and of the principles which operate in the material world. In the first place, to deduce from our observation of physical facts, those principles by which the powers of man may be extended—the useful arts improved and carried to perfection—and the comforts and enjoyments of mankind promoted and increased. In the next place, and chiefly, that our conceptions

of the Creator's power, wisdom, benevolence, and superintending providence, may be enlarged, and that we may be more disposed to pay him that tribute of adoration and gratitude which is due to his name. Every study which sets the supreme Being on one side and nature on the other, is nothing more than an idle amusement—it is lost labour, and productive of little else than ignorance and error, pride and arrogance. To employ our thoughts on a thousand particulars in nature without directing them to the great Creator of all things—to profess to admire the displays of his wisdom, omnipotence, and goodness, while we violate his laws, and persist in a course of avarice or of dissipation—to be conscious of the blessings we every moment receive, and, at the same time, to be utterly unmindful of the hand from whence they flow—are a most glaring inconsistency, a shameful abuse of our understanding, and an act of the most flagrant ingratitude. All our knowledge is of no farther importance to us than as it has an influence on our affections and conduct, and leads us to entertain impressive and reverential ideas of that almighty Being, "in whose hands our breath is, and whose are all our ways."

Let us, then, for the air we breathe, and the numerous benefits we derive from the surrounding atmosphere, display our gratitude, and consecrate all our powers and faculties to the service of Him who "made the earth by his power," and "hath established the world by his wisdom;"—who "causeth the vapours to ascend from the ends of the earth;" who "maketh lightnings with rain, and bringeth the wind out of his treasures," and whose "tender mercies are over all his works." To Him who hath created and redeemed us, all our powers and energies ought to be devoted from henceforth and for ever, for he is worthy to receive all praise, honour, and dominion from men, from angels, and from the inhabitants of all the worlds dispersed throughout the regions of the universe.

PART II.

ATMOSPHERIC PHENOMENA.

This is a subject which would admit of illustration sufficient to occupy a distinct volume; but the present limits will admit of only a very condensed and superficial view of the diversified objects connected with the phenomena of the atmosphere.

The atmospherical phenomena may be arranged under the following heads:—

I. Aqueous meteors; as evaporation, rain, snow, hail, clouds, etc.

II. Winds, sea and land breezes, monsoons, hurricanes, etc.

III. Luminous and fiery meteors, as fire-balls, falling-stars, thunder and lightning, luminous arches, fata morgana, aërial spectres, etc.

CHAPTER I.

AQUEOUS METEORS.

1. Evaporation.—This is a process by which water and other substances are converted into elastic fluids by the influence of heat or caloric. Vapours being lighter than air, are raised into the upper regions of the atmosphere, and afterwards, by a partial condensation, form those clouds which we we see floating around us. They are elastic, invisible substances, like common air, but lighter; being to common air, according to Saussure's experiments, as ten to fourteen. If we expose water to heat, bubbles at first adhere to the sides of the vessel, which by degrees ascend to the surface and burst. These bubbles rise the more rapidly in proportion to the heat. Water is evaporated by the heat of the sun merely, and even without it in the open air; and the vapour rising into the air is condensed into clouds. An immense quantity of vapour is, in this way, raised from the different regions of the earth. In order to estimate the quantity thus raised, Dr. Watson, bishop of Landaff, made the following experiments:—Having provided a large drinking-glass, the area of the mouth of

which was twenty square inches, he placed it with its mouth downwards on a grass-plat which was mown close. The sun shone bright and hot, and there had been no rain for upwards of a month. When the glass had stood on the grass-plat one quarter of an hour, and had collected a quantity of condensed vapour, he wiped its inside with a piece of muslin, the weight of which he had previously ascertained, and, as soon as the glass was wiped dry, the muslin was weighed. The medium increase of weight from various experiments, between twelve and three o'clock, was six grains in one quarter of an hour, from twenty square inches of earth. At this rate of evaporation, computing seven thousand grains troy to one pint of water, and eight pints to a gallon, it may be shown that one thousand six hundred gallons of water would be raised from one acre of ground in twenty-four hours. It is evident that the quantity will be still greater when the ground has been drenched with rain. To prove this, the same philosopher made two other experiments, one of them the day after the ground had been wetted by a thunder-shower; and to ascertain the circumstances more exactly, he took the heat of the earth by a thermometer laid on the grass, which in the first experiment was ninety-six degrees, when the evaporation was at the rate of 1973 gallons from an acre, in twelve hours. The other experiment was made when there had been no rain for a week, and when the heat of the earth was 110 degrees; this experiment gave after the rate of 2800 gallons from an acre in twelve hours; the earth was hotter than the air, being exposed to the reflection of the sun's rays from a brick wall.

Hence it appears that evaporation must form a very important process in the economy of nature. The following are some facts in relation to this process. A much greater quantity of vapour rises during hot weather than during cold, as appears from the preceding experiments. Even where the temperature is the same, it varies according to circumstances. It is least of all in calm weather, greater when a breeze blows, and greatest with a strong wind. In our climate, the evaporation is about four times as great between the vernal and autumnal equinox as in the rest of the year. The degree of cold produced by evaporation is much greater when the air is warmer than the evaporating surface, than when the latter is the warmer of the two. From these and other facts, it is plain that tracts of land which are covered with trees are much colder than those where there is a less surface of vegetable matter, such grounds being found to emit one-third more vapour than the same space covered with water. Hence the

important change of climate which a country undergoes by being cleared and cultivated. America is not the same country at present, either with respect to temperature or salubrity, as it was several centuries ago, when it was covered with woods.

By this perspiration of the globe, it has been estimated that thirty-six inches of water per annum are raised from the surface of all the seas and rivers, and at least thirty inches from all the regions of the land. Hence it follows, that by this constant process of evaporation, 100,000 cubic miles of water are, every year, raised into the atmosphere; the greater part of which, at a certain height, parts with its heat, and is condensed into clouds. Were this prodigious mass of water all to subsist in the atmosphere at once, it would increase about a twelfth part, and raise the barometer nearly three inches. But this never happens; no day passing without rain in some parts of the earth, so that part of the evaporated water is again constantly precipitated. The clouds formed by evaporation are carried by the winds over the land, broken, and precipitated by the action of mountains and trees, and thus rendered the means of watering the soil, and producing fertility throughout every region of the globe. It is owing solely to this process that our clothes, when washed and spread out to the open air, are soon dried. Were there no such process as evaporation in the system of nature, our linens and other clothes, when drenched in water, might remain for centuries without being dried—a circumstance which is seldom thought of by thoughtless men, but which demands our thanksgiving and gratitude. Hence we are called upon by the sacred writers to praise "the name of the Lord," who "causeth the vapours to ascend from the ends of the earth." Psalm cxxxv. 5.

2. *Clouds.*—The aqueous vapours, condensed by cold, or rising in the atmosphere to a region of the air lighter than themselves, form strata of visible vapours, which we call clouds. These masses assume a great variety of shapes and configurations, which sometimes enliven the face of the sky, and at other times cause a gloom and shadow of darkness to overspread the landscape. The distance of the clouds above the surface of the earth varies at different times, and according to the nature of the cloud. Thin and light clouds frequently rise to the height of four or five miles, as they are sometimes seen above the tops of the highest mountains. Their average height may be reckoned about two and a half miles; but some dense clouds frequently descend so low as

to touch mountains, hills, steeples, and even high trees, particularly during thunder-storms. The size of some of these clouds has been estimated to cover a space of fifteen or twenty square miles, and their thickness above a thousand feet. Their motions are generally directed by the winds, excepting when thunder is about to happen; in which case, they seem to move very slowly, and sometimes remain absolutely stationary, which is probably owing to their being impelled by two opposite currents of air.

Clouds have been arranged by modern naturalists into several classes, according to their different configurations, and the regions of the atmosphere where they are generally found. They have been distinguished by Howard into seven modifications, the peculiarities of which are supposed to be caused by the agency of electricity. There are three primary modifications—the cirrus, the cumulus, and the stratus; two which may be considered as intermediate in their nature—the cirro-cumulus, and the cirro-stratus; one which appears to be a compound—the cummulo-stratus; and, lastly, the cummulo-cirro-stratus, or nimbus, a state which immediately precedes the resolution of clouds into rain. These clouds are generally assigned to three atmospherical regions, the upper, the middle, and the lower one; to which a fourth, the lowest, may be added. In the upper region, the atmosphere is in such a state that it can receive and sustain only light and thin vapours, and to this district belongs the cirrus.

The cirrus has the least density of all the forms of cloud, but the greatest height and variety of shape and direction. It is the first indication of serene and settled weather, and first shows itself in a few fibres spreading through the atmosphere. It sometimes looks like a fine whitish thread pencilled on the clear blue sky. These fibres, by degrees, increase in length, and new fibres attach themselves to the sides. The duration of the cirrus is uncertain: in some kinds of weather, its figure is so rapidly and continually changed, that, after turning the eye from it for a few minutes, it will frequently be found almost completely changed. In other cases, it is sometimes visible for many hours and even days together, without much changing its appearance. From its usually curling appearance, this species of cloud is called the mare's-tail cloud.

The cumulus is a cloud of a dense structure, formed in the lower region of the atmosphere, and moving along in the current of wind which is next to the earth. Its first appearance is generally a small irregular spot, which increases in

size, preserves a flat horizontal base, and assumes more or less of a conical figure. Such clouds are sometimes pretty well defined hemispherical masses; at other times, they rise into mountains, ranged in one plane, their silvery summits presenting a beautiful appearance. Before rain they increase very rapidly, and descend low in the atmosphere. Great masses of them, during high winds, are seen in the quarter of the heavens towards which the wind blows, and indicate approaching calm and rain.

The stratus has a mean degree of density; it is the lowest of clouds, and its inferior surface frequently rests on the earth or on the water. The time of its appearance is about sunset, and it disappears soon after sunrise. It comprehends all those creeping mists which, in calm evenings, ascend in spreading sheets, like an inundation of water, from the bottom of valleys. Sometimes it remains quiet, and accumulates in layers, till the atmosphere is capable of sustaining its weight, when it assumes the position of the dark nimbus, and falls in a shower of rain.

The other species of clouds may be briefly stated, which are compound modifications. The cirro-cumulus consists of a collection of small white clouds, of a roundish form, which give to the sky the appearance called dappled, and are, in summer, considered as a prognostic of settled weather; or, at least, of an increase of temperature. They form a very beautiful sky, and are more frequent in summer than in winter. The cirro-stratus is generally in the form of long horizontal streaks, which are ever shifting their figure and position. It precedes wind and rain, the near or distant approach of which may sometimes be estimated from its greater or less abundance. It is frequently seen in the intervals of storms. The form and relative position, when seen in the distance, frequently give the idea of shoals of fish. It is that modification which most frequently exhibits the phenomena of the solar and lunar halo. The cumulo-stratus is a large, lofty, dense cloud, which may be compared to a mushroom, with a very thick, short stem. It rises through the interstices of the superior clouds; and the whole, seen as it passes off in the distant horizon, presents to the fancy mountains covered with snow intersected with dark ridges, rocks, towers, and other objects. Before thunder-storms, it frequently appears reddish. The nimbus is the cloud of rain. Before rain takes place, the clouds are uniformly found to undergo a change, attended with appearances sufficiently remarkable to indicate this as a distinct modification of clouds. It consists of a hori-

zontal sheet, above which the cirrus spreads, while the cumulus enters it laterally, and from beneath.

Clouds are frequently highly charged with electricity. These not only produce violent storms of thunder and lightning, but are sometimes the cause of the destruction of life and the most dreadful devastations. In the year 1772, a bright cloud was observed, at midnight, to cover a mountain in the island of Java, which emitted flames of fire so luminous, that the night became as clear as day. It destroyed every thing for twenty miles around: buildings were demolished, plantations buried in the earth; fifteen thousand cattle, a vast number of horses and other animals, and above two thousand human beings, were destroyed by the agency of this tremendous cloud. On the 29th of October, 1757, in the island of Malta, a little after midnight, a great black cloud appeared, which changed its colour as it approached the city, till it became like a flame of fire, mixed with black smoke, and a dreadful noise was heard on its approach. It tore an English ship to pieces, and carried the masts, sails, and cordage, to a great distance. Small boats, in its course, were broken to pieces and sunk. In passing through the city, it laid in ruins every thing in its way; houses were levelled with the ground, the roofs of churches were demolished; not one steeple was left in its passage, and the bells, together with the spires, were carried to a distance. In this awful catastrophe, the number of human beings killed and wounded amounted to nearly two hundred. Thus it appears that, while clouds serve occasionally as so many screens to abate the heat of the sun in warm countries, and form depositories of rains, which water and fertilize the earth, they are also sometimes used in the hands of the Almighty as instruments for the infliction of his judgments upon the nations; for the clouds are his chariots, the thunder his voice, and he "walketh upon the wings of the wind."

3. *Rain.*—We have already stated that the waters of the earth, by evaporation, yield a certain quantity of moisture to the air, which, being condensed, assumes the form of clouds, floating at different distances above us in the atmosphere. Whatever suddenly disturbs the heat or density of the air, or the electricity of the clouds, occasions the particles of vapour to rush together, and form drops of water too heavy to continue suspended in the atmosphere; they fall in the shape of rain, and increase in size as they fall, by combining with the floating vapours as they pass through them. We have but an obscure conception, however, of the chemical nature of va-

pour, and of the chemical processes which are going on in the production of vapour, and its subsequent resolution into rain. Dr. Thomson has this general remark on the subject, after quoting the opinions of Dr. Watson, Dr. Hales, and others, that "the formation of the clouds and rain cannot be accounted for by a single principle with which we are acquainted. It is neither owing to the saturation of the atmosphere, nor the diminution of heat, nor the mixture of airs of different temperatures; for clouds are often formed without any wind at all, either above or below them: and even if this mixture constantly took place, the precipitation, instead of acounting for rain, would be almost imperceptible." Instead, therefore, of detailing conflicting opinions on this subject, we shall state only a few general facts in relation to rain.

It is worthy of our notice, that drops of rain are always found larger in the lower regions of the atmosphere. In going down a high mountain in the time of rain, the drops gradually increase, till, reaching the bottom, they increase from a drizzling shower to a heavy rain. To ascertain the generality of this fact, Dr. Heberden, in the year 1776, made the following experiment. He placed a rain-gauge on the square part of the roof of Westminster Abbey, another on the top of a neighbouring house, considerably lower than the first, and another on the ground, in an adjoining garden. The rain collected in each was as follows:—top of Westminster Abbey, twelve inches; top of the house, eighteen inches; and on the ground, twenty-two inches; so that more rain was collected in the lower than in the upper rain-gauge. The proportions of rain vary in different months of the year. In summer, we have not so many rainy days as in winter; but the showers are then heavier, the streams of rain closer together, and the quantity which falls is greater than during any other season. Dr. Dalton states that the first six months of the year may be regarded as dry, and the last six as wet months. From certain long-continued observations, it has been inferred that, in spring, it rains oftener in the evening than in the morning; but that towards the end of the summer, oftener in the morning than in the evening; and that storms at this time are apt to occur a little after sunrise. In the progression of the seasons, rain falls at all times during the twenty-four hours, but it has been ascertained that much less falls by day than by night.*

* It is said, that on the 29th of October, 1827, there fell, at Joyeus, in France, twenty-nine inches of rain in twenty-two hours; and, in eleven days, thirty-six inches; which is double that at Paris during the year.

The annual quantity of rain is greatest in tropical countries, and diminishes as we approach the pole, owing to the greater evaporative qualities of the atmosphere in warm than in cold countries. Within the tropic, rain is not of the drizzling character of rain in the temperate zone, but generally falls in such torrents as in other zones would be called waterspouts, and they produce greater floods in a single day than in Europe in six days. Winter is distinguished from summer chiefly by the quantity of rain, which, for six months, is often constant for many days together, and lasts a certain number of hours per day. The rivers, in consequence, overflow, and in many countries produce inundations, which intercept all communications between neighbouring towns and villages. The mean quantity of rain which falls annually in England is thirty-two inches. In the western parts of Scotland, the depth is from thirty to thirty-five inches; in the eastern parts, from twenty-four to twenty-eight inches. At Edinburgh, it is twenty-four inches and a half; and in London, twenty-two and one-fifth. There is more rain in the western parts of Britain than in the eastern, because these parts receive the first clouds as they are brought from the Atlantic by the westerly winds. In the West Indies, one hundred and twenty inches fall annually; and, in the East Indies, from eighty to one hundred inches. At Bombay, eighty-two inches, and at Calcutta, eighty-one inches fall annually.

When mountain-ranges, and other distant objects, appear nearer to us than usual—when sounds are heard more clearly from a distance—when the odour of plants is more than usually powerful, rain may be soon expected. Ducks, geese, and other water-fowls, before the approach of rain, may be seen to throw water, with their bills, over their heads. Cattle may likewise be seen stretching out their necks, and snuffing in the air with distended nostrils. Dogs, closely confined in a room, become drowsy and stupid before rain; the same is observed in cats, though in a less degree; horses neigh frequently; cattle low; the fallow-deer become restless; and swallows fly in a low course. Delicate persons are often affected before rain, with headaches, pains in old sores which have healed, irritability of temper, the aching of corns, and excessive nervousness. Several flowers and plants are prognosticators of rain. When the flower of the chickweed closes, showery weather or continued rain may be expected. The trefoil, the convolvulus, and other plants, contract their leaves before the approach of rain. When the moon is of a pure silvery colour, good weather is indicated;

but when it has a brownish tint, rain may be expected. When stars are surrounded with coloured halos, the approach of rain is indicated.

In the present constitution of our globe, rain—though sometimes attended with a few inconveniences—is essential for promoting the enjoyments both of man and beast. It moistens and softens the earth, and prepares it for being cultivated, and for affording nourishment to the vegetable tribes, which both adorn the landscape of the world, and afford nourishment to the human race and to every species of animated existence. By falling on high mountains, it carries down with it many particles of loose earth, which serve to fertilize the surrounding valleys, and purifies the air from noxious exhalations, which tend, in their return to the earth, to meliorate the soil. It moderates the heat of the air, and forms one of the sources whence fountains and rivers are supplied. Without the influence of rain, trees, shrubs, and flowers would soon wither, sicken, and die, and every land be then turned into a barren wilderness. But when the clouds, at seasonable periods, pour down their watery treasures, all sublunary nature is invigorated and refreshed, and the vegetable productions of the soil are made verdant and flourishing, and adorn the surface of the earth with their gay attire and diversity of colours. In the language of the Psalmist, "The little hills rejoice on every side. The pastures are clothed with flocks; the valleys also are covered over with corn; they shout for joy, they also sing." He who at first formed the earth for man, "watereth the ridges thereof abundantly," maketh it "soft with showers," blesseth "the springing thereof," and crowneth the year with his goodness. It is represented by the inspired writers as the peculiar prerogative of Jehovah to send rain upon the earth: "Are there any among the vanities of the Gentiles that can cause rain? or can the heavens give showers? Art not thou He, O Lord our God?—for thou hast made all these things." The effects produced by the want of rain are emphatically described by these writers: "Thy heaven that is over thee is as brass, and the earth that is under thee as iron." "The field is wasted, the land mourneth; for the corn is wasted. . . . Be ye ashamed, O ye husbandmen; howl, O ye vine-dressers, for the wheat and for the barley; because the harvest of the field is perished. The vine is dried up, and the fig-tree languisheth; the pomegranate-tree, the palm-tree also, and the apple-tree, even all the trees of the field, are withered. . . . How do the beasts groan! The herds of cattle are perplexed, because

they have no pasture; yea, the flocks of sheep are made desolate; . . . for the rivers of waters are dried up, and the fire hath devoured the pastures of the wilderness." Joel i. 10—12, 18, 20.

4. *Snow.*—Snow consists of such vapours as are frozen while the particles are small. It differs from hail and hoar-frost, in being crystallized, which they are not. When a flake of snow is examined by a magnifying-glass, the whole of it will appear to be composed of fine shining spicula, diverging like rays from a centre. As the flakes fall down through the atmosphere, they are continually joined by more of these radiated spicula, and thus increase in bulk, like the drops of rain or hail-stones. Many of the flakes of snow are of a regular figure, for the most part stars of six points, and are as perfect and transparent ice as any we see on a pond or river. Their forms present an almost endless variety, are often very regular and beautiful, and reflect, with exceeding splendour, the rays of the sun. When they are very large, they are said to indicate the approach of thunder. The different forms which the flakes of snow exhibit, when viewed through microscopes, are represented in figure 6. These

Fig. 6.

crystals of snow are from one-third to one thirty-fifth of an inch in diameter, in their natural size. Experiments have

been made, which prove that snow is twenty-four times lighter than water, and that it fills up ten or twelve times more space at the moment of falling, than the water produced from it, when melted. It is worthy of remark, that previous to the fall of snow, and during its continuance, the temperature continues at about 32 degrees. The lightness of snow, although it is firm ice, is owing to the excess of its surface in comparison to the matter contained under it. Its whiteness is owing to the small particles into which it is divided; for ice, when pounded, will become equally white.

Snow is frequently formed in the lower regions of the atmosphere. A very cold stream of air admitted into a room in which the contained air is much warmer, and loaded with watery particles, will occasion its formation. In the huts of those who inhabit the arctic regions, snow is frequently formed in this manner. Dr. Robertson states that, in a crowded assembly-room in St. Petersburg, a stream of cold air was accidentally admitted into the room by a gentleman breaking a pane of glass, on which the vapour in the air was immediately congealed, and fell in the form of snow-flakes. In Siberia, Nova Zembla, and other northern regions, the same phenomenon frequently happens. Snow occurs in all regions of the globe at a certain height above the level of the sea, but it falls more abundantly on plains as we proceed from the equator to the poles. In the arctic regions, snow falls nine days out of ten in the months of April, May, and June, and often to a depth of two or three inches in an hour. Among the mountains of Germany, Italy, and Switzerland, snow is sometimes accumulated to such an extent as to produce the most terrific and destructive effects, as in the case of the rolling avalanche. An avalanche is a mountain-mass of ice, or frozen snow, which is sometimes loosened from its base, and descends from the mountains with a force so terrible, that it crushes the traveller beneath its power, and buries hamlets and villages in a common grave. In the year 1749, the whole village of Rucras, in the canton of Grisons, in Switzerland, was covered, and, at the same time, removed from its site, by an avalanche of this description. But this change, which happened in the night-time, was effected without the least noise; so that the inhabitants were not aware of it; and, on awakening in the morning, could not imagine why daylight did not dawn. A hundred persons were dug out of the snow, sixty of whom were still alive, the insterstices between the snow containing sufficient air to support life. Not many years ago, an instance occurred of a family buried under one

of these avalanches, and who continued in that situation for above a fortnight, remaining all that time in utter darkness, and incrusted in a body of snow several hundred feet in thickness. A massy beam supported the roof against this enormous pressure; and a milch ass, that happened to be thus incarcerated with the people, furnished sufficient nourishment for the support of life, till they were, at length, restored to the light of day.

The great Dispenser of universal bounty has so ordered it, that snow is eminently subservient, as well as all his other works, to his benevolent designs. As the winter cold is much more hurtful to vegetables than to animals, the plants would perish, if their roots were not preserved by some covering. God has, therefore, ordained that the rain, which in summer cools and revives the plants, should, in winter, fall in the form of a soft wool to cover the vegetables, and to guard them from the inclemency of frosts and winds. It prevents the internal heat of the earth from escaping, and forms a safe covering to the tender herb, till the winter cold has abated under the influence of the genial spring.

5. *Hail.*—Hail, which is a more compact mass of frozen water than snow, is formed by the congelation of vapour in the higher regions of the atmosphere. The drops of hail assume various figures, being sometimes round, at other times pyramidal, angular, thin, and flat, and sometimes stellated with six radii, like the small crystals of snow. When hailstones are broken open, or cut across, they are sometimes found within to be of a spongy structure; sometimes the interior presents a very beautiful radiated appearance, and not unfrequently exhibits regular and very remarkable concentric plates. They are often of considerable dimensions. They vary in size from that of a small seed, to that of a boy's marble; and, in some instances, they have been found as large as the eggs of a goose; the small generally falling in the more northerly climates, and on the tops of mountains, and the larger in France, Spain, Italy, and other countries, towards the south of Europe. Hailstones have fallen in Scotland, which have been proved to weigh five ounces. In North America, they have sometimes been picked up weighing fifteen ounces; and on October 5th, 1831, one fell at Constantinople which weighed more than a pound! The average velocity with which they fall, has been estimated at seventy feet per second, or at the rate of fifty miles an hour; and consequently, their great momentum, arising from this velocity, frequently renders them very destructive, particularly

in hot climates. They beat down the crops, strip trees of their leaves, fruits, and branches, and sometimes kill even large beasts and men. A few years ago, a tremendous storm happened in Gloucestershire, accompanied with a most remarkable hail-shower. The masses of ice which fell in places where the storm most fiercely raged, bore no resemblance to the usual state of hailstones in magnitude or *formation*, most of them being of a very irregular shape, broad, flat, and ragged, and many of them measuring nine inches in circumference. They appeared like fragments of a vast plate of ice, broken into small masses, by its descent towards the earth.

The phenomena attending the formation and fall of hail are but imperfectly understood, though it is certain they are connected with electricity, and hence, the frequent occurrence of hail-showers during violent storms of thunder and lightning. They occur principally in the temperate regions of the globe, less frequently between the tropics, and are almost unknown in the frigid zones. They are, also, more frequent in summer than in winter. In the south of France, and the adjacent countries, much damage has been produced by the ravages of hail-storms. To avert such ravages, hail-rods have lately been erected on the same principle as lightning-rods. They consist of lofty poles tipped with metallic wires communicating with the earth. By thus subtracting the superabundant electricity of the clouds, it is supposed that the formation of hail might be prevented. It has been estimated by the "Linnean Society of Paris," from numerous experiments made in different districts, that "if these hail-rods were established through the whole of France, it would occasion an annual saving to the revenue of *fifty millions* of francs." It is also stated that, in many districts which were formerly year after year devastated by hail, the instrument has been adopted with complete success, while, in neighbouring districts, not protected by hail-rods, the crops have been damaged as usual.

6. *Dew.*—Dew is vapour condensed into visible drops. It begins to be deposited about sunset, and is most abundant in valleys and plains near rivers and other collections of water, and abounds on those parts of the surface which are clothed with vegetation. In England, the dew is observed, like the drops of drizzling rain, upon the leaves of grass and other vegetables, upon wood, glass, porcelain, etc., or upon the earth, which is thereby rendered sensibly moist. It falls more copiously in spring and summer than at any other times

of the year. In countries situated near the equator, the dews are generally observed in the morning throughout the year; and in some places in the east, where rain seldom falls, they are so copious, as, in a great measure, to supply its deficiency. During the heat of the day, a great quantity of vapour is thrown into the atmosphere from the surface of the earth and waters. When the evening returns, if the vapour has not been carried off by currents, it will happen that more remains diffused in the general atmosphere than the temperature of the night will permit to subsist. A decomposition of the aqueous atmosphere then commences, and is continued till the general temperature and aqueous pressure arrive at an equilibrium, or till the returning sun puts an end to the process.

Hoar-frost, which appears like a powdery crystallization on trees and herbage, is only frozen dew. The conversion of dew into hoar-frost is another wise arrangement of Nature, by which plants are protected from the severity of a freezing cold atmosphere. *Fogs* are clouds which float on the surface of the earth; and clouds are fogs in the higher regions of the atmosphere. From many elevated places they may be seen moving in the valleys, and from the valleys they may frequently be seen creeping along the sides of the mountains.

CHAPTER II.

WINDS.

1. Winds *in general.*—Wind is the motion of a body of air flowing from one place to another. The earth being surrounded by a fine invisible fluid, extending several miles above its surface, is acted upon by heat and cold arising from different causes. This appears to be the general cause of the phenomena of winds; and, according to the force or velocity with which the masses of air move, we use the terms, a breeze, a gale, a storm, a tornado, a whirlwind, a hurricane, &c. When a fire is made in the open air, the rarefied part of that fluid will ascend in a current, and the cooler and denser air will rush in on all sides, in consequence of which a wind is generated, and blows constantly towards the fire.

The wind thus produced will be too inconsiderable to be perceived at any great distance, but the rarefaction which arises from natural causes may be such as to agitate our atmosphere sufficiently to produce those torrents of air which have always a powerful effect in nature, and which sometimes overwhelm and destroy the fairest and most superb productions of human art. Among the causes which produce this rarefaction of the atmosphere, and generate wind, the heat of the sun is not the least powerful. When the solar rays, by their reflection from the earth's surface, have heated or rarefied a portion of the surrounding air, the air so rarefied ascends into the higher regions of the atmosphere, and the colder air, by which it was surrounded, moves forward in a sensible current to fill the vacuity. Likewise, when a condensation of vapour in the atmosphere suddenly takes place, giving rise to clouds which speedily dissolve in rain, the temperature of the surrounding air is sensibly altered, and the colder rushing in upon the warmer, gives rise to a sudden gust of wind. In regard to the particular causes which produce the various winds which prevail in different regions of the globe, different opinions have been entertained by philosophers. And, therefore, instead of examining theories and doubtful opinions on this subject, the writer will confine himself to the statement of a few facts respecting the different species of winds as they are found to operate in different countries.

2. *General, or permanent winds.*—Winds are commonly divided into three classes, namely, general, periodical, and variable winds. General winds are those which are permanent, and blow always in the same direction, and have received the name of trade-winds. These winds prevail chiefly within the tropics, and a few degrees beyond. On the north of the equator, their direction is from the north-east, varying at times a point or two of the compass each way. On the south of the equator, they proceed from the south-east. These winds constantly range in one direction, but never extend further than 30° from the equinoctial, either north or south. In the Atlantic and Pacific oceans, under the equator, the wind is almost always easterly; more to the northward, it generally blows between the north and east; and, more to the southward of the equator, it blows between the south and east. The origin of these winds appears to be as follows:—the powerful heat of the torrid zone rarefies the air of that region; in consequence of this rarefaction, the air rises, and, to supply its place, a colder body of air from each of the temperate zones moves towards the equator. But these north and south

winds pass from regions where the rotatory motion of the earth's surface is less to those where it is greater. Unable at once to acquire this new velocity, they are left behind; and, instead of being north and south winds, as they would be if the earth's surface did not turn round, they become north-east and south-east winds.

3. *Periodical winds, or monsoons.*—Those winds, which blow in a certain direction for a time, and, at certain stated seasons, change, and blow for an equal space of time from the opposite point of the compass, are called *monsoons.* During the months of April, May, June, July, August, and September, the wind blows from the southward or south-eastward over the whole length of the Indian ocean, namely, between the parallels of 28° north, and 28° south latitude, and between the eastern coast of Africa, and the meridian that passes through the western part of Japan; but, in the other months, October, November, December, January, February, and March, the winds in all the parts of the Indian ocean shift round, and blow directly contrary to the course they held in the former six months. These winds suffer partial changes in particular places, owing to the form and position of the lands, and other circumstances. When they shift, or when the south-west monsoon is about to commence, it is ushered in by vast masses of clouds from the Indian ocean, accompanied with violent blasts of wind, which are succeeded by floods of rain, during which, the lightnings flash without intermission, and the thunders roll with loud and deafening peals; and, when it ceases, the rain pours down in large volumes. This terrific commotion of the elements lasts for many days.

4. *Land and sea-breezes.*—These are another kind of periodical winds which are common on the coasts and islands situated between the tropics. During the day, the wind blows for a certain number of hours from the sea to the land; but, when evening arrives, it changes its direction, and blows as many hours from the land to the sea. The cause of these alternations appears to be as follows:—water, being a better conductor of heat than earth, is always of a more even temperature. During the day, therefore, the land becomes considerably heated, the air rarefied, and, consequently, in the afternoon, a breeze sets in from the sea, which is less heated at that time than the land. On the other hand, during the night, the earth loses its surplus heat, while the sea continues more even in its temperature. Towards morning, therefore, a breeze regularly proceeds from the land towards the ocean,

where the air is warmer, and, consequently, more rarefied than on the shore.

5. *Variable winds.*—In most countries to the north and south of the tropics, the winds are very irregular and uncertain, and vary in their direction at certain seasons of the year. In Germany, the east wind is most frequent at Gottingen, Munich, Weissemburg, Dusseldorf, Erford, and Buda; the south-east, at Prague and Wirtzburg; the north-east, at Ratisbone; and the west, at Manheim and Berlin. Along the whole south-west of France, the wind blows most frequently from the north, north-west, and north-east; on the west coast, from the west, north-west, and south; and, on the north coast, from the south-west. In Great Britain, the north-east and south-west winds more frequently prevail, along with occasional north-west and south-east winds. From ten years' registers kept by the Royal Society, it appears that, in London, the winds blow in the following order: from the south-west, 112 days; north-east, 58; north-west, 50; west, 53; south-east, 32; east, 26; south, 18; north, 16. From the same register, it appears that the south-west wind blows at an average more frequently than any other wind during every month of the year; that the north-east blows most constantly during January, March, April, May, and June, and that the north-west wind blows oftener from November to March, and more seldom during September and October, than any other months. In Scotland, the south-west is by far the most frequent wind over all the country, especially on the west coast. At Edinburgh, the westerly winds have been found to blow 230 days, and the easterly 135. At Saltcoats, in Ayrshire, the south-west wind blows three-fourths of the year, and along the whole coast of Moray, on the north-east side of Scotland, it blows for two-thirds of the year. East winds are common over all Britain, during April and May, but their influence is felt most severely on the eastern coast.

In our northern region, winds seldom excite much alarm, nor are they often attended with the disastrous results which are frequent in the tropical regions. It has, however, sometimes happened, even in England, that winds have produced the most appalling and destructive effects. In the great storm which happened on the 27th of December, 1703, the extraordinary power of the wind created a noise hoarse and dreadful, like thunder, which appalled every heart. Horror and confusion seized upon all, whether on land or at sea. One hundred and twenty-three persons were killed by the falling of dwellings, among whom were the bishop of Bath and his

lady, by the fall of the episcopal palace. Eight thousand perished in the Severn and the Thames, and in ships blown away, and never heard of afterwards. Land, houses, churches, corn, trees, rivers—all were damaged by its fury. Small buildings were swept away as chaff before the whirlwind; above 800 dwelling-houses were laid in ruins; 2000 stacks of chimneys were blown down in London; 15,000 sheep were destroyed on the banks of the Severn, and 20,000 in the county of Kent; 300 ships, 500 wherries, 300 ship-boats, and 100 lighhters and barges, were entirely lost. The Eddystone Lighthouse was precipitated in the surrounding ocean, along with its ingenious architect and those that were with him. The damage done in the city of London alone, by this storm, was computed at above two millions of pounds sterling! Such are some of the dreadful effects of that invisible fluid which surrounds us, when put in rapid motion by the force of currents. Light as its particles seem to be, no human wisdom or power can, in such cases, avert its force, or withstand its dreadful and destructive agency, in allusion to which the Almighty is represented as riding "on the wings of the wind," and directing "the whirlwind and the storm."

6. *Noxious and poisonous winds.*—These winds prevail most generally in southern climes. Of these, the harmattan is a very singular wind, which blows periodically from the interior parts of Africa towards the Atlantic ocean. The season in which it prevails is, during the months of December, January, and February. It comes on at any hour of the day, and continues five or six days; and there are generally three or four returns of it every season. This wind is distinguished by a fog or haze, and extreme dryness; no dew falls during its continuance, vegetables wither, and the grass becomes dry like hay. The dryness is so extreme that the covers of books, though closely shut up in a trunk, are bent as if exposed to the fire. Household furniture is damaged, panels of wainscots split, and veneered work flies to pieces. The human body, likewise, feels the parching effects of the harmattan; the eyes, nostrils, lips, and palate, are rendered dry and uneasy; the lips and nose are inflamed, and there is a troublesome sensation of pricking heat on the skin. If the harmattan continue, the scarf-skin peels off, first from the hands and feet, and afterwards from the rest of the body.

The sirocco is a wind which resembles, in some of its effects, the harmattan. It sometimes blows for several days together, and its medium heat is calculated at 112°; it is

fatal to vegetation, and destructive to mankind, especially to those who are not natives of the country; it depresses the spirits in an unusual degree; it suspends the powers of digestion in such a manner, that those who venture to eat a heavy supper generally die during the night. The sick frequently sink under the pressure of their diseases, so that it is customary, in the morning after this wind has continued a whole night, to inquire who is dead. During the continuance of this wind, all nature appears to languish, vegetation withers and dies, the beasts of the field droop; the animal spirits are too much exhausted to admit of the least bodily exertion, and the spring and elasticity of the air appear to be lost. In the city of Palermo, in Sicily, where it frequently prevails, the inhabitants shut their doors and windows to exclude the air; where there are no window-shutters, wet blankets are hung on the inside of the windows, and the servants are kept continually employed in sprinkling the apartments with water, and the streets and avenues of the city appear at such times to be nearly deserted. This wind is frequently felt in Greece, Italy, the Levant, and other parts of southern Europe; it is occasioned by currents of heated air from the deserts of Zahara in Africa; but happily it is not of long continuance. In Sicily, it seldom lasts longer than thirty-six or forty hours.

The samiel, or mortifying wind, is, perhaps beyond all others, dreadful in its effects. It generally blows on the southern coasts of Arabia, and the deserts near the city of Bagdad; and is supposed to have been the pestilence of the ancients, frequently killing all those who are involved in its passage. What its malignity consists in, none can tell, as no one has ever survived its effects to give information. It has been said that it frequently assumes a visible form, and darts in a kind of bluish vapour along the surface of the country. The natives of Persia and Arabia talk of its effects with terror; they describe it as under the conduct of a minister of vengeance, who governs its terrors, and raises or depresses it as he thinks proper. The camels, either by instinct or experience, have notice of its approach, and are so well aware of it, that they are said to make an unusual noise, and cover their noses in the sand. It blows over the desert in the months of July and August, and rushes with violence to the very gates of Bagdad, but never injures any person in the city. To escape its effects, travellers throw themselves as close as possible to the ground, and wait till it has passed by, which is commonly a few minutes. As soon as they who have life dare to rise up, they examine how it fares with their

companions by pulling at their arms or legs; for, if they are destroyed by the wind, their limbs are absolutely mortified, and will come asunder. An extraordinary blasting wind is felt occasionally at Falkland's Islands, but it seldom continues above twenty-four hours. It cuts the herbage down as if fires had been made under it, so that the leaves are parched up and crumbled into dust. Fowls are seized with cramp, so as never to recover; and men are oppressed with a stopped perspiration, heaviness at the breast, and sore throats.

The simoon is a hot wind which prevails in Egypt, Arabia, Syria, and the adjacent countries. When it begins to blow in Arabia, the atmosphere assumes an alarming aspect. The sky becomes dark and heavy, the sun loses his splendour, and becomes of a violet colour, and the air is thick from the subtle dust with which it is loaded. At first, the wind is light and rapid, and not remarkably hot; its temperature, however, soon increases, till it ranges at upwards of 128°. When it occurs, all animated bodies discover it by the change it produces in them. The lungs are contracted and become painful, respiration is short and difficult, the skin parched and dry, and the body consumed by an internal heat. The streets are deserted, and the dead silence of night reigns everywhere. The inhabitants of towns and villages shut themselves up in their houses, and those of the desert in their tents, or in wells dug in the earth, where they wait the termination of this destructive heat. The only refuge travellers have from it is, to fall down with their faces close to the ground, and to continue as long as possible without drawing in their breath. Mr. Bruce thus describes it, in his journey through the desert:—"At eleven o'clock, while we contemplated the top of Chiggre, where we were to solace ourselves with water, Idris, our guide, cried out with a loud voice, 'Fall upon your faces, for here is the simoon.' I saw from the south-east a haze, in colour like the purple part of the rainbow, which did not occupy twenty yards in breadth, about twelve feet from the ground, and it moved very rapidly, for I could scarce turn to fall upon the ground, with my head to the north, when I felt the heat of its current plainly on my face. We all lay flat on the ground as if dead, till Idris told us it was blown over. The meteor or purple haze which I saw was indeed passed, but the light air which still blew was of heat to threaten suffocation. For my part, I found distinctly in my breast that I had imbibed a part of it, nor was I free of an asthmatic affection till I was in Italy two years afterwards."

Hurricanes are violent tempests of wind, accompanied with thunders and lightnings, rain, or hail. These fearful concussions of the atmosphere happen most frequently in the range of the West India Islands, and about the Cape of Good Hope. The forerunner of these hurricanes, when first seen, is only like a small black spot on the verge of the horizon, called by sailors the bull's eye. All this time a perfect calm reigns over sea and land, while at length, coming to the place where its fury is to fall, it invests the whole horizon with darkness. During its approach, a hollow murmur is heard in the cavities of the mountains, and animals, sensible of its approach, run over the fields to seek for shelter. Nothing can be more terrible than its violence when it begins. The sun, which, but a moment before, blazed in meridian splendour, is totally shut out, and a midnight darkness prevails, except that the air is incessantly illuminated with gleams of lightning, so vivid that one can see to read, and the rain pours down in torrents. All the elements seem to arm themselves for the destruction of human labours, and even of the scenes of nature herself. The velocity of the wind is such, that corn, vines, sugar-canes, forests, houses, boats, ships, are swept away, or buried in the deep.

A tornado is a sudden and violent gust of wind from all points of the compass. It partakes somewhat of the nature of a hurricane, but is still more violent in its effects. The winds seem to blow from every quarter, and settle upon one destined place, with such fury that nothing can resist their vehemence. When they have met in their central spot, the whirlwind begins with circular rapidity. The sphere every moment widens, as it continues to turn, and catches every object that lies within its attraction. The mariner, within the reach of its influence at sea, must try all his power and skill to avoid it, which, if he fail of doing, there is the greatest danger of his going to the bottom. Tornadoes most frequently rage along the coasts of Guinea, and other parts of western Africa.

Such are a few brief sketches of the phenomena of noxious and stormy winds. It is evident that they did not exist in the primitive state of our globe; for the operation of such agents of terror and destruction appears altogether inconsistent with the idea that man is at present in a paradisaical state, and possessed of that innocence and moral purity in which he was created. It appears incompatible with the idea of an Almighty Intelligence, possessed of boundless benevolence, that innocent beings should be so frequently subjected to the influence of such dreadful agents, by which they are swept

from the living world in a manner so appalling and terrific. Man is, therefore, a creature who has fallen from his primitive state of integrity; and such fearful agents, and many others, as the volcano and the earthquake, are so many proofs and evidences of the depravity and fallen state of the human race; otherwise they would not be permitted to inhabit a world where so many destructive influences are in operation. An important change appears to have taken place in the constitution of the atmosphere at the period of the universal deluge, which probably may have have given rise to many of the physical evils connected with this part of our terrestrial system; which may, in after ages, be in a great measure removed, when the earth shall be cultivated throughout its whole extent, and universal peace and brotherhood prevail among all nations. Notwithstanding, however, the occasional operation of these destructive agents to which we allude, the arrangements connected with our globe, in their prominent bearings, and considered as a whole, evidently display the long-suffering, the tender mercy, and the goodness of Jehovah, and should lead us to humble ourselves in his presence, under a sense of our manifold deviations from the path of his commandments.

The velocity of winds varies, from the gentlest breeze or an imperceptible movement, to a hundred miles an hour. Light airs may be considered as moving at the rate of from one to three miles an hour, or from a foot and a half, to four feet and two-fifths, per second; a breeze, from four to six miles an hour; a brisk gale from ten to sixteen miles an hour; a fresh gale, from twenty to twenty-five miles; a strong gale, from thirty to thirty-five miles; a hard gale, from forty to forty-five miles; a storm or tempest, fifty miles; a great storm, sixty miles; a hurricane, eighty miles; a violent hurricane, tearing up trees, throwing down houses, etc., moves at the rate of one hundred miles an hour.

Notwithstanding the occasional ravages of winds, they produce many beneficial effects in the system of nature. They serve as ventilators for purifying the atmosphere; they dispel fogs and noxious vapours; they agitate the waters of the ocean, and prevent them from stagnation and putrefaction; in the heat of summer they fan us with gales and gentle breezes. By their mechanical force, windmills and other machinery are set in motion, and ships impelled across seas and oceans to the remotest corners of the globe, to promote commerce, learning, religion, and the mutual intercourse of human beings.

CHAPTER III.

LUMINOUS AND FIERY METEORS.

1. *The Aurora Borealis.*—This is one of the most splendid phenomena which appears in the visible sky, especially when its coruscations diffuse themselves over the whole face of the heavens. The appearances of the aurora may be arranged under the following particulars:—1. A horizontal light, like the morning twilight or break of day. This light generally appears in the north or north by west, and sometimes seems as if it broke out from a few darkish clouds. 2. Fine, slender, luminous beams, well defined, and of a dense light. These frequently continue a half or a whole minute, apparently at rest, but more frequently with a quick lateral motion, that is, from east to west, or the contrary. 3. Flashes pointing upwards, or in the same direction with the beams, which they always succeed. These are only momentary, and have no lateral motion, but they are generally repeated many times in a minute. They appear much broader, more diffuse, and of a weaker light than the beams; they grow gradually fainter till they disappear, and sometimes continue for several hours, flashing at intervals. Sometimes they are confined chiefly to the northern region of the heavens, and at other times illuminate the whole sky with their fantastic coruscations. Such are some of the general appearances of the aurora borealis, but they are strikingly varied at different times, and it is difficult accurately to describe the shifting and splendid phenomena they present.

The aurora has been occasionally seen in all ages: it is spoken of by Herodotus, Xenophon, Diodorus Siculus, Homer, Virgil, and Ossian, the Highland bard. Aristotle, in his work on meteors, describes it as "an appearance observed by night in calm weather, resembling flame mingled with smoke, or the distant appearance of burning stubble; the predominant colours being purple, bright red, and blood colour." It has been more frequently observed in Great Britain since the year 1716, when, on the 6th of March, it appeared with a splendour which attracted universal attention, and was considered by many as prognostic of wars, famine and pestilence, and a foreign race of princes.

The following is a description of an aurora, as seen by Dr.

Dalton :—"Attention was first excited by the remarkably red appearance of the clouds to the south, which afforded sufficient light to read by at eight o'clock in the evening, though there was no moonlight in the north. From half-past nine to ten, P. M., there was a large luminous horizontal arch to the southward, and one or more concentric arches northward. At half-past ten o'clock, streamers appeared very low in the south-east, running to and fro from west to south; they increased in number, and began to approach the zenith apparently with an accelerated velocity, when all of a sudden the whole hemisphere was covered with them, and exhibited such an appearance as surpasses all description. The intensity of the light, the prodigious number and velocity of the beams, the grand intermixture of all the primitive colours in their utmost splendour, variegating the glowing canopy with the most enchanting scenery, afforded an awful, but, at the same time, pleasing and most sublime spectacle. Every one gazed with astonishment, but the uncommon grandeur of the scene only lasted only one minute; the variety of colours disappeared, and the beams were converted into the flashing radiations; but even then it surpassed all other appearances of the aurora; in short, the whole hemisphere was covered with it."

The writer had occasion to witness a splendid and somewhat terrific display of this phenomenon, in the vicinity of Dundee, on the 17th November, 1835. A little before nine o'clock, P. M., the coruscations first began to appear, which in a short time diffused all the brightness which appears in a moonlight evening. About ten o'clock, the aurora shone in all its splendour, when coruscations, or streams of light, more than thirty or forty degrees in length, appeared to issue from a central point near the zenith, and to extend themselves in every direction, south, north, east, and west, like the meridians on an artificial globe. The most singular feature displayed by this aurora was that of a number of streams of light of a dark red colour, like blood, and resembling expansive sheets of flame, which were seen in all directions mingling their streams with the more brilliant yellow coruscations, and giving to the whole celestial concave an appearance of terrific grandeur, which seemed to impress the mind of every beholder with awe and terror. This display continued during the night till four o'clock next morning, and was visible over the whole island of Great Britain. In London, it produced such an effect, that the policemen, ignorant of its nature, hurried to and fro through all the avenues of that city in search of fires, which they imagined had burst forth from every

quarter. On the evening of September 29, 1847, about ten o'clock, a brilliant and rather uncommon aurora made its appearance, near Dundee. The sky was strongly illuminated in the north, and numbers of spiral coruscations shot upwards towards the zenith. But its most striking peculiarity was that, on a sudden, and in a portion of the sky which was perfectly clear, an immense stream of light began to blaze with a quivering motion, like a huge serpent, or in a form like the letter s, extending forty or fifty degrees in length, and several degrees in breadth. Such streams of brilliant light, which appeared and vanished with all the rapidity of lightning, were to be seen over most regions of the sky.

This phenomenon appears more frequently, and displays itself in still greater splendour in the polar regions than in our country. It is also said that, in those regions, a hissing sound is heard during its continuance. During the long nights of winter in those countries, particularly in Lapland and Greenland, its radiations, along with the light of the heavenly bodies, are sufficient to guide the inhabitants in their journeys, and to enable them to engage in all the other avocations of life. In the northern parts of Siberia, the aurora begins with single bright pillars rising in the north, which, gradually increasing, comprehend a large space in the heavens, rush about from place to place with incredible velocity, and at last cover almost the whole sky up to the zenith, and produce an appearance as if a vast tent were expanded in the heavens glittering with gold, rubies, and sapphires. It has been found, likewise, that these brilliant phenomena are visible in the south polar regions as well as in the north. The general appearance of the aurora borealis is pretty well described by Thomson, the poet of the "Seasons."

"Silent from the north
A blaze of meteors shoots; ensweeping first
The lower skies, they all at once converge
High to the crown of heaven, and all at once
Relapsing quick, as quickly re-ascend
And mix and thwart, extinguish and renew
All ether coursing in a maze of light."

Various opinions have been formed as to the cause which produces the phenomena of the aurora. Most philosophers seem to agree that it is of an electrical nature, as its appearance can be imitated by artificial electricity. Dr. Faraday considers it as highly probable, "that it is a luminous accumulation of electricity flowing from the equator to the poles, for the restoration of electric equilibrium." But whatever may be the physical cause of the aurora, it presents to our

view one of the most beautiful, sublime, and at the same time awful and mysterious phenomena which appear in our sky —while its coruscations sometimes cover, with inconceivable magnificence, the concave of the whole hemisphere, changing their positions every moment, now resembling vast pyramids, or innumerable columns, now vanishing in a moment, leaving the heavens sombre and black, and now returning with increased splendour, shedding a matchless glory over the heavens. Such striking phenomena evidently display the majesty and glory of the Creator and his power to cause the invisible elements of nature to produce the most grand and diversified scenery—and although their mode of operation is not thoroughly discovered, they are, doubtless, intended to subserve beneficial purposes in the system of creation.

2. *Luminous arches.*—These are somewhat striking phenomena, which sometimes precede, or accompany the aurora borealis, but they make their appearance only at very distant intervals. The writer has seen only four or five of these arches within the space of the last thirty years. One of the most brilliant of the arches appeared on the 27th of August, 1846, and was first perceived a few minutes before nine o'clock in the evening. It was a grand and beautiful luminous arch, which stretched from one side of the heavens to the other, forming a most resplendent object in a clear and serene sky. Its highest point was about seventy-five degrees above the southern horizon—a little above the brilliant star, Vega Lyra. Like all the other arches of this kind he has seen, it had a gradual motion downward towards the southern horizon, so that in the course of twenty minutes it was considerably below the star now mentioned. Its direction was from east by north, to west by south, or nearly at right angles with the magnetic meridian—which seems to indicate that it is connected with the operation of the magnetic principle. This is the exact direction of all the luminous arches now referred to, and they are all evidently connected with the appearance of the aurora borealis, and may be considered as a peculiar modification of this phenomenon. Its breadth was greater than that of a common rainbow; there appeared no prismatic colours, but a pure brilliant white, contrasting most beautifully with the deep azure of the sky. An aurora appeared at the same time in the north and north-west, but its coruscations were not very vivid, and continued only for a very short time. The arch began first gradually to disappear at its extremities, near the eastern and western horizon, and,

about forty minutes after having been first seen, it was completely dissipated. The height of such phenomena above the earth has been variously estimated. Euler estimated them at 1000 miles; Boscovich, at about 800; Bergman, at 460; and Dr. Dalton, at 150 miles, which is perhaps nearest the truth. Whatever may be the height of the luminous arches, we have reason to believe that the elevation of the aurora borealis above the earth is the same, as they evidently are produced by the operation of the same cause.

3. *Fire-balls.*—These are a species of luminous or fiery bodies, which are occasionally seen to wing their flight through the upper regions, with a considerable degree of velocity and splendour. In tropical climates, these bodies are more frequently seen than in our more temperate regions. The following are a few brief descriptions of some of the meteors. Mr. Barham relates that, when he was riding in Jamaica, one evening, he beheld a ball of fire apparently about the bigness of a bomb, swiftly falling down with a great blaze. Approaching the place where it fell, he found the ground strangely broken up and ploughed, and several holes appeared of the bigness of a man's head, and all the green herbage burned up near the holes; at the same time, a strong smell of sulphur. In the year 1676, a great globe of fire was seen at Bononia, in Italy, about forty minutes after sunset. It passed with a most rapid course, and at the rate of not less than one hundred and sixty miles a minute, and at last stood over the Adriatic sea. It crossed all Italy in its course, and, by computation, it was found that it could not have been less than thirty-eight miles above the surface of the earth. Wherever it approached, the inhabitants below could distinctly hear it with a hissing noise, resembling that of a firework. It was heard to go off with a violent explosion. Its magnitude, when at Bononia, appeared twice as long as the moon, one way, and about as broad the other. It was estimated to be a mile long and half a mile broad.

One of the most striking and extraordinary meteors of this kind made its appearance on the 18th of August, 1783, about nine o'clock in the evening. It was seen in all parts of Great Britain, from the Shetland isles to the English channel, over all France, and the greatest part of Italy, and is supposed to have described a tract of at least one thousand miles over the surface of the earth. It appears to have burst and re-united several times, and the first bursting which was noticed was somewhere over Lincolnshire, in England. Its appearance produced universal wonder and alarm. When it was ob-

served at Brussels, the moon appeared quite red, and the illumination was so great as totally to obliterate the stars. A report was heard sometime after it disappeared, which was loudest in Lincolnshire, and afterwards in the eastern parts of Kent. A hissing sound was said also to accompany its progress. At Greenwich, two bright balls, parallel to each other, led the way, and were followed by an expulsion of eight others. The balls were tinted first with a pure bright light, then followed a yellow mixed with azure, red, and green, which, with a coalition of bolder tints, and a reflection from the other balls, gave the most beautiful rotundity and variation of colour with which the human eye could be charmed. The height of this fire-ball was reckoned at from seventy to ninety miles, its diameter was estimated at nearly two miles, and its velocity at about 1000 miles a minute. The same year, on the 4th of October, at forty-three minutes past six in the evening, another meteor appeared, nearly of the same description, but much smaller and of shorter duration. It was first perceived to the northward as a stream of fire, like the common shooting-stars, but large ; and presently burst out into that intensely bright bluish flame, which is peculiar to such meteors. It was nearly globular, but left behind it a dusky red streak of fire. After moving ten degrees in this state, it became suddenly extinct without any explosion. Its height was estimated at between forty and fifty miles.

As to the physical causes which produce these extraordinary meteors, we are still in a great measure ignorant. The general opinion among philosophers is, that they owe their origin to the operation of electricity. The velocity with which these meteors wing their flight—the electrical phenomena attending them, the lambent flames and sparks proceeding from them—their connection with the aurora borealis, on whose appearance luminous balls have been seen formed and darting about with great velocity—and their general motions, which are constantly from or towards the north, or north-west —have been viewed as so many arguments corroborative of their electrical origin. Still it is difficult to account for all the phenomena exhibited by these bodies by electricity alone, since some of these bodies appeared to be of a denser and more compact structure than electricity could produce.

4. *Shooting or falling stars.*—These are meteors which are frequently seen darting through the sky, in the form of stars, and most frequently accompanied with a train of light. The nature of these bodies has not yet been well ascertained,

and philosophers have of late been disposed to alter their former opinions respecting them. It appears, from certain late observations made at Breslau by Professor Brandes and his pupils, that the height of some shooting-stars is not less than five hundred miles, and that they move at the rate of eighteen miles in a second. A most extraordinary and wonderful display of the phenomena of shooting-stars has of late occurred in different places, particularly in America. On the evening of the 12th and the morning of the 13th November, 1833, a shower of these meteors happened at Boston, New York, and other places, and their number was considered to equal one-half of the flakes which fill the air in an ordinary fall of snow. It was calculated that, in some places, they fell at the rate of 36,000 per hour, and the phenomena lasted more than seven hours. At Boston, the number of shooting-stars which were seen was estimated at two hundred and forty thousand. Similar phenomena, though not in such numbers, have appeared in various other places, and in the subsequent years, from the 12th to the 15th November, and hence they have been denominated the November meteors. M. Arago, the French philosopher, is of opinion, that such extraordinary phenomena cannot well be accounted for, unless it be supposed that, besides the planetary bodies which revolve around the sun, there are myriads of smaller bodies, which only become visible at the moment when they come within our atmosphere and assume a meteoric appearance; and that they move in groups, and also singly. Dr. Olmsted, of New Haven, who particularly investigated the meteoric showers of 1833, deduces the following among other conclusions:—That the distance of the body whence they emanated was about 2238 miles—that they entered the earth's atmosphere with a velocity of four miles per second—that some of the larger meteors must have been bodies of great size, not less than a mile in diameter—and, that they consisted of portions of a nebulous body which revolves around the sun, in one hundred and eighty-two days.

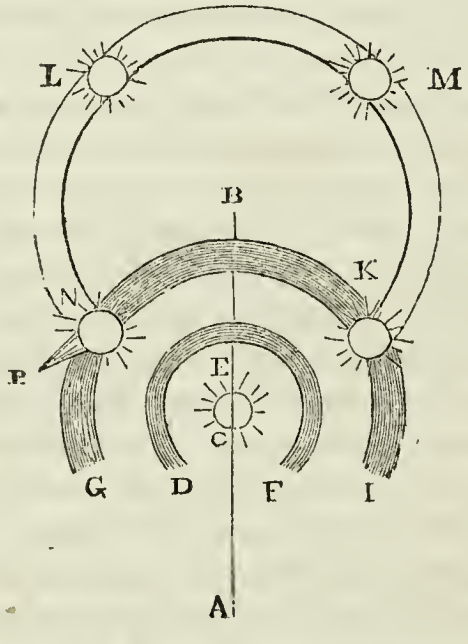
We may learn from such phenomena that, if the universe were not under the superintendence of a wise and benevolent Being, or if the powers of nature were left to act at random, the world in which we live might be subjected to manifold disasters from unknown bodies and unseen causes, from which we have hitherto been protected.

5. *Parhelia, or mock suns.*—A parhelion is a meteor in the form of a very bright light appearing on one side of the sun, and resembling that luminary. They generally seem

about the size of the true sun, not quite so bright, though sometimes they are said to rival their parent luminary in splendour. When there is a number of them, they are not equal to each other in brightness, and externally they are tinged with colours like the rainbow. They differ in number and size; but they all agree in breadth, which is that of the apparent diameter of the sun. Appearances of this kind have been observed, both in ancient and in modern times. Gassendi, the Italian astronomer, relates, that in 1635 and 1636, he often saw one mock sun. Two were observed by M. de la Hire, in 1689, and the same number by Cassini, 1693; Mr. Grey, in 1700; Dr. Halley, in 1702; the Rev. Mr. Hamilton, in Dublin, in 1783; but the most remarkable appearances of this kind were seen at Rome by Scheiner; by Muschenbroeck, at Utrecht; and by Hevelius, at Sedan; by the former, four mock suns were observed, and by the latter seven.

The phenomena of these meteors observed by Scheiner, at Rome, is represented at figure 7, in which A is the place of the observer; B, his zenith; C, the true sun; A B, a plane

Fig. 7.



passing through the observer's eye, the true sun, and the zenith. About the sun, C, there appeared two concentric rings, not complete, but diversified with colours. The lesser of them, D E F, was fuller and more perfect; and though it was open from D to F, yet those ends were perpetually endeavouring to unite, and sometimes they did so. The outer of these rings was much fainter, so as to be scarcely percepti-

ble. It had, however, a variety of colours, but was very inconstant. The third circle was very large, and entirely white, passing through the middle of the sun, and everywhere parallel to the horizon. In the intersection of this circle, and the outward iris, G K I, there broke out two parhelia, N and K. The brightness of the middle of them was something like that of the sun, but towards the edges they were tinged with colours like the rainbow. The parhelion N was a little wavering, and sent out a spiked tail, N P, of a colour somewhat fiery. The parhelia at L and M were not so bright as the former, but were rounder and white, like the circle in which they were placed. The parhelion N disappeared before K, and while M grew fainter, K grew brighter, and vanished the last of all. Parhelia have been visible for two, three, and four hours together, and in North America they are said to continue some days, and to be visible from sunrise to sunset.

6. *Thunder and lightning.*—These sublime and terrific phenomena are well known to every individual, and are occasionally displayed in every region of the globe. A thunder-storm usually happens in calm weather, though sometimes it has been accompanied with furious winds. A dark cloud is observed to attract other clouds to it, by which it continually increases both in magnitude and apparent density ; and when it has thus accumulated to a great size, its lower surface swells in particular parts towards the earth, and light flimsy clouds are sometimes seen flying under it, and continually changing their ragged shape. During the time the cloud is thus forming, the heavens begin to darken apace, the whole mass sinks down, wind arises, and frequently shifts in squalls, flashes of lightning are seen to dart from one part of it to another, and often to illuminate the whole mass and the surrounding landscape. When the cloud has acquired a sufficient expansion, the lightning strikes the earth in two opposite points ; its paths lying through the whole body of the cloud. Heavy rains, and sometimes hail-showers, accompany these dire phenomena, till, after numerous successive discharges, the cloud rarefies, and the storm ceases. The scene of a thunder-storm is generally in the middle regions of the atmosphere ; and it is not a frequent case that an electrical discharge is made into the earth. The lightning darts from one cloud into another, and when the clouds are high, there is no danger to persons or objects on the surface of the earth. But when the cloud is low, and within the striking distance of the earth, when the flashes appear to strike perpendicu-

larly, and when only a second or two elapse between seeing the flash and hearing the report of the thunder, every object around may be considered as within the limits of danger; for then the lightning strikes into some part of the earth, and every object in the line of its course is liable to be injured. We may ascertain the distance of a thunder-cloud, by counting the number of seconds or pulsations that intervene between seeing the lightning and hearing the first sound of the thunder, allowing about 1142 feet, or 380 yards for every second. Thus, if two seconds intervene, the distance is 760 yards; if three seconds, 1140 yards; if four and a half seconds, 1710 yards, or nearly a mile, etc. During a thunder-storm, the lightning sometimes assumes different forms. Sometimes it appears as balls of fire, moving with great velocity: this is the most dangerous species of lightning, and where they strike, corn-yards are set on fire, and sometimes flocks of sheep, herds of cattle, and human beings, are instantly killed. Another form is that of zigzag lightning, which most frequently accompanies thunder-storms. It is likewise destructive, but not to the same extent as the ball-lightning. The next species is the sheet-lightning, which appears in the form of a lambent flame, or a sudden illumination, without any determinate form. It is never known to do any injury.

As to the cause of thunder-storms, it is now ascertained, beyond dispute, that lightning and electricity are identical. This had been, long ago, surmised, after the attention of philosophers had been directed to the subject of electricity. It was observed that lightning, in its course, took the best conductors of electricity, such as bell-wires, and gildings; that it burned, exploded, and destroyed conducting substances, as electricity does; that it struck the most elevated objects, as trees and spires; that the crooked form of zigzag lightning was similar to that of an electric spark; and that it affected the nervous system, and changed the polarity of the mariner's needle, as electricity was found to do. This was, at last, put to the test of experiment by Dr. Franklin, by elevating, during a thunder-storm, a kite, with a metallic point on the head of it, when he drew an electric spark from the cloud by means of a key, connected with the wet string, which was connected with the kite. Nearly at the same time an experiment, somewhat similar, was performed by M. Dalibard, at Marly de Ville, about fifteen miles from Paris. These experiments were made in 1752, and since that period, lightning, and the electric matter, have been considered as the same; though there are still many phenomena connected

with thunder-storms of which we are ignorant. The grand practical use to which Dr. Franklin applied his discovery, was to secure buildings from being damaged or destroyed by lightning; which is accomplished by fixing a pointed metallic rod higher than any part of the building, and communicating with the earth. This wire the lightning will seize upon, in preference to any other part of the building, by which it is conducted to the earth without injuring the inhabitants.

Maxims during a thunder-storm.—When in the open fields, avoid trees, but be near them—say at the distance of thirty or forty feet—as high objects are more likely to be struck with lightning than those which are low. When walking in the open air, avoid ponds, rivers, streamlets, and every mass of water; for water, being a conductor of electricity, might determine the lightning to the place we occupy. Do not avoid rain, as it is safer, in a thunder-storm, to be completely drenched than otherwise. When in a house, persons should avoid sitting near the fireplace, as it brings us in connection with the highest part of the building, and which contains such conducting substances, as the grate, the fender, and fire-irons. Bell-wires, mirrors, gildings, lustres, and other metallic substances, should also be avoided. The safest position is in the middle of a large room, at a distance from conducting substances, with our chair placed on a mattrass.

In the preceding pages, we have taken a cursory survey of the nature and properties of the atmosphere, and of the phenomena it frequently presents, and have noticed the evidences of Divine wisdom and beneficence as displayed in the arrangements connected with this admirable appendage to our globe. A devout contemplation of this subject is worthy of the serious attention of every rational and Christian mind; for all the works of God are intended to display to intelligent beings certain parts of the character and attributes of the Almighty, and to inspire us with love and gratitude for those merciful and benevolent arrangements by which our lives are preserved, and our happiness and comforts secured. The system of the material world, in all its varieties, may be considered as one of the revelations given by God to man, in order that we may trace, from his external operations, visible to every eye, something of the nature of that Almighty Being who at first brought all things into existence, and who, every moment, superintends all their movements. Hence we are informed, by an inspired writer, that the "invisible things of

Him from the creation of the world are clearly seen, being understood by the things that are made, even his eternal power and Godhead."

Had man continued in primeval innocence, in the complete exercise of his moral and intellectual faculties, this would, perhaps, have been the only revelation of which he stood in need. But, in his present fallen state, the investigation and study of the material world are not sufficient to lead him to the knowledge of the true God, and to guide him in the way that leads to immortal happiness. Hence it happened that even the wisest sages of antiquity, who were destitute of any other revelation, completely failed in attaining to just conceptions of the Eternal Divinity, of the worship and homage he required, of the duties they ought to perform, and of their eternal destination. "Professing themselves to be wise, they became fools, and changed the glory of the uncorruptible God into an image made like to corruptible man, and to birds, and to four-footed beasts, and creeping things."

The religion of nature is glaringly deficient in directing us to correct views of the attributes of the true God, and particularly of the conceptions we ought to form of his moral character, as a Being possessed of strict and impartial justice and eternal rectitude, and whether he be disposed to the exercise of mercy and love. Hence, some of the ancient philosophers denied his existence, and others embraced the notion of a multiplicity of gods, celestial, aërial, terrestrial, and infernal; and the moral characters and actions attributed to such deities were distinguished for every thing that was wicked, base, cruel, and licentious. The light of nature can afford us no certain and indubitable evidence of the immortality of the soul, a future state of eternal rewards and punishments, or of a future and glorious resurrection: for many opposite and discordant opinions prevailed on this subject among those who were destitute of Divine revelation; some of them absolutely denying the existence of such a state as a vulgar error; while others represented it as altogether uncertain, having no solid foundation for its support. The light of nature can convey no proper notion of a creative Power that could produce the universe out of nothing, nor of the time and manner in which the world was created and arranged. Hence, one sect of heathen philosophers held that the world was eternal; and another, that it was formed in its present admirable order by a fortuitous concourse of innumerable atoms. It can afford us no certain information respecting the origin of evil, and the cause of that depravity and

misery, which exist among mankind; and, in short, it can point out no method by which those who have offended God may be certainly restored to his favour, and a reconciliation effected between God and man; so that his mercy may be exercised without the violation of his justice, and the pardon of sinners rendered consistent with the honour of his laws and the wisdom and equity of his government. From nature, therefore, there arises no sufficient comfort to sinners to warrant hopes of forgiveness; but, on the contrary, anxious and endless solicitude about the means of appeasing the Deity. Hence the various modes of sacrificing, and the numberless superstitions which overspread the heathen world, but which were unsatisfactory to the wiser part of mankind, even in the times of pagan darkness and ignorance.

While ignorant of the important and interesting truths now adverted to, we can enjoy no solid happiness in the present state, nor any cheering prospects in reference to a future and eternal world. But, on all these subjects, so interesting to every human being, the Christian revelation throws an effulgence of light and evidence, and affords every satisfaction to the anxious mind which it can desire. It has "brought life and immortality to light," and shed a radiance over the mansions of the tomb, and the scenes of a future world; it has unravelled the origin of evil, and the cause of all those miseries and moral abominations which have prevailed in the world; and, above all, it has disclosed the gracious purposes of the God of mercy and love towards our fallen and apostate world, and opened the way by which sinners may be pardoned and restored to the Divine favour, in full consistency with all the perfections of the Divinity, and the honours of his universal government. For thus runs the declaration of the Most High to all the children of men: "God so loved the world that he gave his only begotten Son, that whosoever believeth in him should not perish, but have everlasting life." He sent his Son into our world, as a messenger of peace, "to bear the sin of many," "to bring in everlasting righteousness," to make "intercession for the transgressors," to vindicate the honours of his broken law, to abolish death, and to open the way to the mansions of glory in the heavens, to men of all nations, kindreds, and languages, who receive the record he hath given of his Son, and submit to the method of salvation he hath devised. He hath set forth his Son to the world to be "a propitiation through faith in his blood, to declare his righteousness for the remission of sins, . . . that he might be just and the justifier of him which believeth in

Jesus." It is, therefore, "a faithful saying, and worthy of all acceptation, that Christ Jesus came into the world to save sinners," even the chief. And all who receive the salvation thus proffered, will consecrate themselves to his service, and, by the aid of the Holy Spirit, prosecute a course of obedience, "denying ungodliness and worldly lusts," and living "soberly, righteously, and godly in the present world." Every sin and violation of the Divine law will be carefully avoided; every holy disposition, every heavenly temper, and every Divine virtue and grace will be sedulously cultivated; love to God and man will pervade all the faculties of the soul, and be displayed in the general tenor of the conduct; and, by pursuing such a course of action, the individual will be gradually prepared for the nobler contemplations and exercises of that higher sphere of existence, where there is "fulness of joy," and "where there are pleasures for evermore."

From what we have now stated, we may fairly conclude, that all our contemplations of the works of nature, and all our investigations of the system of the visible creation, ought to be conducted in connection with the views and discoveries unfolded by Divine revelation. The two revelations which God has made to us, when properly studied, will be found not only in perfect harmony, but to throw a mutual light on each other; so that what may appear deficient in one is supplied by the other. While we contemplate the manifestations of Divine power, wisdom, and goodness, in the arrangements and operations of nature, we perceive the same attributes illustrated in the records of revelation; and, in addition to these, we perceive what nature cannot teach us, that God is a Being of perfect and eternal rectitude, of inviolable faithfulness, of boundless benevolence; ready to forgive, and rich in mercy to all who call upon him in truth:—a Being who fills immensity of space with his presence, who possesses the most intimate knowledge of all creatures and events throughout creation, and who superintends all the movements of the material universe. To whatever scene of nature we direct our attention, we find sentiments in scripture adequate to express every emotion of the soul while engaged in such contemplations. Are we contemplating the immense number and variety of animated beings which people the earth, the waters, and the air, and the ample provision made for their accommodation and subsistence—where can we find language more appropriate to express our feelings than in these words of the Psalmist, "O Lord, how manifold are thy works, in wisdom hast thou made them all: the earth is full of thy riches! So

is this great and wide sea, wherein are things creeping innumerable, both small and great beasts.—These wait all upon thee ; that thou mayst give them their meat in due season. That thou givest them—they gather ; thou openest thy hand —they are filled with good." When we survey the structure of the human frame, and consider the vast number of bones, muscles, veins, arteries, lacteals, and other parts, all curiously combined, performing such a variety of functions, and all contributing to life and enjoyment—can we refrain from adopting the expressive language of the Psalmist? "I will praise thee ; for I am fearfully and wonderfully made: marvellous are thy works!—how precious are thy thoughts unto me, O God! how great is the sum of them! If I should count them they are more in number than the sand." When we consider the amazing structure of the heavens—the immense magnitude and number of the mighty orbs contained within the canopy of the sky—that millions upon millions of suns and worlds stretching into the immensity of space far beyond the limits of our vision, or even of our imagination, form only a small portion of the universal empire of the Almighty ; and when the mind is overwhelmed and lost, on the view of this stupendous scene—where shall we find language to express our emotions, more emphatic and appropriate, than in such passages as these? "Canst thou by searching find out God? Canst thou find out the Almighty unto perfection? Great is our Lord and of great power: his understanding is infinite ;—his greatness is unsearchable.—The heavens declare the glory of God ; and the firmament showeth his handiwork.—All nations before him are as nothing ; and they are counted to him less than nothing, and vanity—who doeth great things past finding out ; yea, and wonders without number.—Great and marvellous are thy works, Lord God Almighty! Who can utter the mighty acts of the Lord? Who can show forth all his praise?"

In short, the man who recognises the truths of Divine revelation must feel a higher degree of pleasure and satisfaction in contemplating the scenes of creation, than the man who either discards or overlooks the revelations contained in the sacred oracles. To a man who is hastening to the grave, uncertain whether his intellectual powers and consciousness shall exist beyond the limits of the present state—of what avail is it that he has acquired a partial knowledge of some of the departments of the visible world, when all his knowledge shall be lost at the hour of dissolution, and no farther prospect remains of his ever again resuming such studies and

investigations, and of beholding the mysteries and wonders of the universe more fully unfolded? He may be filled with wonder at many of the astonishing processes going forward in the animal, vegetable, and mineral kingdoms; his mind may be overpowered with admiration and astonishment at the vast extent of the material universe, and at the myriads of worlds it contains, but he can entertain no hopes of seeing such wondrous scenes more fully unravelled and displayed in the light of immortality. But the Christian, who looks forward to the nobler employments of a future world, may with certainty indulge in the hope that in the light of that world, the veil which now intercepts our view of the wonders of creation will be removed, and the glories of the Divinity, as displayed in all his works, more fully unfolded. For the inhabitants of that world are represented as celebrating the perfections of the Most High in such strains as these—"Great and marvellous are thy works, Lord God Almighty!" evidently indicating that the veil is partially removed from the hidden scenes of creation, and their minds expanded to take in large and comprehensive surveys of the wonders of the universe, so as to perceive them to be "great and marvellous." And again, they exclaim, "Thou art worthy, O Lord, to receive glory, and honour, and power; for thou hast created all things, and for thy pleasure they are and were created."

THE END.

CATALOGUE OF BOOKS

PUBLISHED BY

E. C. & J. BIDDLE,

No. 6 South Fifth Street,

PHILADELPHIA.

SCHOOL AND CLASSICAL BOOKS.

COBB'S NEW SERIES OF SCHOOL BOOKS.

The works composing this series, which are named below, have been extensively introduced into schools throughout the Union, and in not a few cases where the character of the schools has made them universally known, and placed them in a high rank among the Seminaries of our country: *e. g.*, the Public Schools of the City and County of Philadelphia, of the cities of New York, Baltimore, Brooklyn, Rochester, &c.

COBB'S NEW FIRST BOOK. It has been the design of the author, in this little book, analytically to arrange the alphabet in lessons (pages 4 and 5,) so that a *part* of the letters may be learned at a time, the vowels being placed first; and, that the practice of teaching or sounding the letters by course, all at ONE LESSON, may be abandoned.

He has also given easy words of one, two, and three syllables, in which there are no double vowels, diphthongs, or double consonants in the same syllable, or any silent consonants; but, only the long and short sounds of the vowels, thus making the lessons both easy and attractive, and by the ease with which the lessons can be learned, in connection with the cuts interspersed throughout the book, combining amusement with instruction.

COBB'S NEW SPELLING BOOK; containing nearly all the common primitive, and a great portion of the derivative words of the language, together about 15,700 words, (other spelling books rarely containing more than 10,000,) is based upon the *principle*, that to enable the scholar to learn rapidly, and permanently to impress the orthography of each word upon his mind, the words should be presented so *classed*, that the *eye* and *ear* will act in concert or unison. To effect this desirable object, the words are all classed with reference to *six* general principles.

I. All the words in the spelling lessons are classed according to similarity of termination, both in regard to *sound* and *orthography*.

II. All *single* and *double* consonants are separately classed.

III. All the different *diphthongs* are separately classed.

IV. Different consonants, which might be confounded with, or mistaken for other consonants, owing to their various or similar sounds, are separately classed.

V. All silent consonants are separately and alphabetically classed.

VI. The verbal distinctions are all separately classed, and their peculiarities pointed out. Words of this class—as *pair, pare, pear; rain, rein, reign; abuse, excuse; advise, advice; prophecy, prophesy*, &c., &c., &c.; in all other Spelling Books, are *intermingled* with other words, causing great *perplexity* and *embarrassment*, and subjecting the scholar to an *interminable* round of *guessing* at their orthography.

COBB'S NEW JUVENILE READER, No. 1.
COBB'S NEW JUVENILE READER, No. 2.
COBB'S NEW JUVENILE READER, No. 3.
COBB'S NEW SEQUEL.
COBB'S NEW NORTH AMERICAN READER. These five Reading Books contain moral, instructive, descriptive, historical, and interesting lessons, adapted to the capacities of every age.

The Reading Lessons are graduated by the number of syllables in each word, and adapted to the capacities of the children who use them.

All the words in each Reading Lesson, which are not contained in the preceding lessons of these books, are formed into a Spelling Lesson (placed immediately *before* the Reading Lesson) in which each word is divided, accented, pronounced, defined, and the part of speech designated.

The different meanings of a word are given; that applicable to the Reading Lesson being always placed *first*, and printed in *Italics* when other definitions are given which are not equally applicable to the Reading Lesson.

Questions are placed at the end of each Reading Lesson, so that from the answers given, the teacher may know how far and how correctly the scholar has understood what he has read.

By the arrangement of this series of Reading Books the scholar is constantly exercised in *spelling* and *defining*, in connection with his Reading Lesson. The advantages of this plan, especially as relates to defining are so obvious as to require no argument to prove them.

THE NEW AMERICAN SPEAKER.

Being a Selection of Speeches, Dialogues, and Poetry, for the Use Schools. By Thomas Hughes.

From the Rev. S. B. How, D. D., late President of Dickinson College; and Rev. Dr. Westbrook, Principal of Female Seminary, and Rector of Rutgers College Grammar School.

The New American Speaker contains judicious selections from the writings of different authors, and is well adapted to the use of our schools.
New Brunswick, February 17, 1836.

SERIES OF ETYMOLOGICAL CLASS BOOKS.

1. THE FIRST BOOK OF ETYMOLOGY. By James Lynd, Prof. of Belles Lettres. in Delaware College.
2. THE CLASS BOOK OF ETYMOLOGY. By Professor Lynd.
3. AN ETYMOLOGICAL DICTIONARY OF THE ENGLISH LANGUAGE. By John Oswald. New edition, with a key by Prof. Lynd.

This series has been adopted, in whole or in part, for use in the Public Schools of Philadelphia, Baltimore, New York, Brooklyn, Troy, Utica, Hartford, Charlestown, &c. &c.

From Professor J. S. Hart, Principal of Philadelphia Central High School, author of an English Grammar, Class-Books of Prose and Poetry, an Exposition of the Constitution of the United States, &c.

CENTRAL HIGH SCHOOL, *Philadelphia, June* 15, 1847.

GENTLEMEN,—I have examined with unusual satisfaction the First Book and Class-Book of Etymology, by Mr. James Lynd. These books, both in their plan and exe-

cution, give evidence of having been prepared by one practically acquainted with the difficulties of the subject, and able successfully to meet them. I have long considered the study as one of primary importance, and I am free to say, that I think Mr. Lynd's work the greatest advance that has yet been made towards a practical and efficient method of teaching it. The conviction has been for some time gaining ground, that the study of the analysis of words into their elements, of the meaning of these elements and the method of combining them—in other words, the study of Etymology—is essential, especially to the mere English scholar, to a proper and intelligent comprehension of the language. These exercises, also, like all rational exercises connected with the study of language, have been found to be one of the most efficient means of disciplining the youthful mind. But hitherto serious difficulties have been experienced from the want of text-books precisely adapted to the necessities of English scholars; and many teachers have omitted what they believed to be an important branch of primary instruction, because no method of teaching it had been presented that seemed sufficiently practical. Mr. Lynd's books, I think, will go far to remove this difficulty. They are evidently prepared with care, with reference to the wants of scholars rather than the display of erudition; and on a plan that can hardly fail to commend itself at sight to the experienced teacher.

Very respectfully, your obedient servant, JOHN S. HART.

To Messrs. E. C. & J. Biddle.

Philadelphia, April 29, 1847.

MESSRS. E. C. & J. BIDDLE.—Having given the works on Etymology by Mr. James Lynd a very careful examination, it affords me great pleasure to express my unqualified approbation of the manner in which he has treated his subject.

The first book is well adapted to the wants of beginners in the study of Etymological Analysis, and in the hands of the judicious teacher, cannot fail to be a most valuable aid in training the young pupil to a correct knowledge of the meaning and application of a large portion of the words of our language; while the larger work is fully adequate to the completion of the most extended course of instruction in this branch, pursued in our Public Schools.

I regard the books as superior to any of their class with which I am acquainted; and trust they will receive the patronage to which their merit entitles them.

Yours, &c. A. T. W. WRIGHT,

Principal of Boys' Model School,

[*Now Principal of Female Public Normal School, Philada.*]

Philadelphia, May 3, 1847.

MESSRS. E. C. & J. BIDDLE.—I have examined with more than ordinary care and interest, the series of text-books published by you upon the subject of "*English Etymology.*"

Independently of the actual knowledge given to a pupil by the radical analysis of a language, I have found this study so eminently successful in the cultivation of a peculiar quickness and discipline of mind in the learner, that it has assumed, in my estimation, a far higher rank among the branches of a common education than that usually assigned to it.

Now although the text-books we already have upon this subject are useful, I do not hesitate to say that the series published by yourselves is far better. The simplification of the study, and the multiplication of elementary exercises for beginners, as given in the introductory book, the correction of various philological errors that have appeared in similar works, the addition of the more immediate and intelligible Gothic roots, the compilation of a copious "*Key,*" and the supplementary catalogue of synonymes; all these are additions and improvements such as render the series superior, in my estimation, to any yet published, and such as must, in the hands of competent teachers, render them highly useful, wherever they may be introduced.

With great respect, THOMAS K. BEECHER,

Principal N. E. P. Grammar School for Boys,

[*Now Principal of Hartford Pub. High School.*]

From Professor C. D. Cleveland, author of "Latin Lessons," "Latin Grammar," &c.

GENTLEMEN.—In republishing "Oswald's Etymological Dictionary," enriched as it is by the sensible and well-written "Introduction" of Dr. Keagy, you have done a real service to the cause of *sound education.* It is the best work of the kind (designed for schools) that I have yet seen, and it must have an extensive circulation. For in every well-regulated school, taught by competent masters, Etymology will form a prominent branch of study as long as there is an inseparable connection between clearness of thought and a correct use of language.

Yours, respectfully, C. D. CLEVELAND.

I regard Oswald's Etymological Dictionary as a work superior to any thing of the kind that has hitherto fallen under my observation. It has evidently been executed with much labor and ability—and, if properly used, it cannot fail to afford much

valuable aid to all classes of students, and particularly to those who, being destitute of an acquaintance with the Greek and Latin classics, are desirous of obtaining an accurate knowledge of the terminology of science, and of the structure and derivation of the English language. ROBERT MILLIGAN,

Professor of English Literature in Washington College, Penna.

Philadelphia, May 12, 1845.

GENTLEMEN,—I have used Oswald's Etymological Dictionary as a class-book in my school for many years, and have found it well adapted to the purposes designed by its author. It is the best work of the kind with which I am acquainted; contains the roots and definitions of a larger number of words than can be found in any other work of the same class—and the additions made by the American editor, Dr. Keagy give it increased value, by furnishing the student with much interesting matter.

Yours, A. T. W. WRIGHT,

Principal of Model Public Grammar School.

M'MURTRIE'S SCIENTIFIC LEXICON.

A DICTIONARY OF TERMS used in the various branches of Anatomy, Astronomy, Botany, Geology, Geometry, Hygiene, Mineralogy, Natural Philosophy, Physiology, Zoology, &c. By Henry M'Murtrie, M. D. etc., Professor of Anatomy, Physiology, and Natural History, in the Central High School of Philadelphia.

A text-book in the Central High School of Philadelphia.

From Samuel George Morton, M. D., Vice-President of the Academy of Natural Sciences, of Philadelphia; formerly President of the Association of American Geologists and Naturalists; author of "Crania Americana," "Crania Egyptica," &c. &c.

I have examined Dr. M'Murtrie's Dictionary of Scientific Terms, and believe it to be admirably adapted to the explanation of the numerous technicalities that are inseparably connected with every department of Science. Such a glossary is indeed indispensable to the learner, who by its aid will find every step facilitated, and much time saved. SAMUEL GEORGE MORTON.

Philadelphia, October 27, 1847.

From Prof. Paul B. Goddard, M. D., of Franklin Medical College, Philada.

Philadelphia, October 30, 1847.

DEAR SIR,—I have looked over a copy of your "Lexicon Scientiarum," and am very much pleased with it. It cannot fail to be of the utmost value to students of general science; and to students of medicine it must prove invaluable. I have placed it upon my office table, where it is daily consulted by my pupils, who say it is just the thing they wanted. Yours, &c. PAUL B. GODDARD.

To Prof. M'Murtrie.

From Prof. J. K. Mitchell, M. D., of Jefferson Medical College, Philada.

Philadelphia, November 2, 1847.

MY DEAR SIR,—Having just enjoyed the satisfaction of looking over your "Lexicon Scientiarum," I cannot help telling you how greatly indebted I, for one, am to you for the great trouble and profound erudition you have applied so successfully to an object of the highest importance. A good compendium of terms of art was a *desideratum*, felt alike by the learned and the illiterate, and you have removed this defect of our book-shelf in such a manner as to leave nothing to desire. I am of opinion that your opusculum will be found especially useful to students of medicine, who do not find in dictionaries of their own art, the many terms of kindred sciences frequently occurrent in their most elementary works.

I am, &c., yours respectfully, J. K. MITCHELL.

To H. M'Murtrie, Esq., M. D.

From Prof. James McClintock, M. D., of Philadelphia Medical College.

Philadelphia, November 4, 1847.

MY DEAR SIR,—Accept my thanks for the copy of your Lexicon which you sent me. Before I received it I had seen the book, and was so pleased with it I had determined to put it into the hands of my students. At one of my earliest lectures I shall avail myself of the opportunity to recommend it to the members of our class.

In the hope that the success of the work will transcend your most sanguine expectations, I am, very respectfully, &c.

To Prof. M'Murtrie. JAMES M'CLINTOCK.

From Prof. W. Darrach, M. D., of Pennsylvania Medical College, Philada.

After a few weeks' use of Prof. M'Murtrie's "Lexicon Scientiarum," I am satisfied that it sustains its title-page and the subsequent remarks of its worthy and learned author.

By avoiding repetitions, so common in dictionaries, excluding generic names and ordinary words; and by giving the etymology of every term in not only the character of the language of the root, but also in the Italic letter, Doctor M'Murtrie has becomc the first to accomplish not only a *very portable*, but also a *very cheap* and admirable Lexicon of *exclusively* Scientific Terms, covering not less than *ten* departments of Science.

W. DARRACH.

Philadelphia, November 9, 1847.

From James B. Rogers, Professor of Chemistry, in the Medical Department of the University of Pennsylvania.

Philadelphia, November 19, 1847.

Dear Sir,—You will please accept my thanks for the copy of the "Lexicon Scientiarum" you were kind enough to send me. I have looked over it with pleasure, and feel convinced, that in its publication you have conferred a substantial benefit upon *all classes* of Scientific Students; I shall therefore take especial care to bring it before the noticc of my class. I am with great rcspect, yours, &c.

Prof. H. M'Murtrie. JAMES B. ROGERS.

From John F. Frazer, Professor of Chemistry and Natural Philosophy, in the Collegiate Department of University of Pennsylvania.

Dear Sir,—I admire thc plan and cxccution of your "Scientific Lexicon" exceedingly. The want of such a book is very much felt, not only in your institution, but whcrcver subjects connected with the sciences which it includes are studied; and I am sure that for the purposes for which it is dcsigned, nothing could be better suited than it is. I am with great respect, yours truly,

Prof. H. M'Murtrie, M. D. JOHN F. FRAZER.

COMPENDIUM OF ENGLISH LITERATURE.

A COMPENDIUM OF ENGLISH LITERATURE, chronologically arranged, from Sir John Mandeville (14th century) to William Cowper, (close of 18th century;) consisting of Biographical Sketches of the Authors, choice Selections from their works; with Notes explanatory and illustrative, and directing to the best Editions, and to various criticisms. Designed as a text-book for the highest classes in Schools and Academies, as well as for private reading. By Chas. D. Cleveland.

Adopted as a text-book in the Public Grammar Schools of Philadelphia, the Public High School of Hartford, Wesleyan Female College, Cincinnati, &c. &c.

From Rt. Rev. Alonzo Potter, D. D.

Philadelphia, Dec. 9, 1847.

Having, some years since, meditated a similar undertaking, I can appreciatc, in a measure, the difficulties with which you wcrc called to contend, and the skill with which you have surmounted them. The selections scem to me to bc made with much taste and judgment, and I cannot but regard this volumc as a very valuable addition to our School Literature. The interest with which a young kinswoman, in whose hands I have placed it, is studying it, is an earnest of the reception which it must meet in the more advanced classes of our higher schools for both sexes.

ALONZO POTTER.

From Rev. G. Emlen Hare, D. D., Principal of the Academy of the Protestant Episcopal Church, Philadelphia.

A book giving well selected specimens of the English Literature in different periods, and within such compass as to makc it suitable for the usc of the higher classes in academies, was, until lately, a dcsideratum. Professor Cleveland seems to have supplied the want with an ability and success which few besides himself could bring to the work. With great confidence I recommend the Compendium of English Literature to the attention of parents, instructors, and the lovers of elegant learning generally.

G. EMLEN HARE.

Philadelphia, January 5, 1848.

From Rev. John Ludlow, D. D., Provost of the University of Pennsylvania.

The public are greatly indebted to you for placing before our youth this Compendium of English Literature. I hope it will command the attention which it certainly deserves; and if my name would have any influence, I would most earnestly recommend it to every young lady especially, who desires a "finished" education.

Departing from my usual custom, if you or your publishers should deem this note of any use to extend the circulation of your valuable work, it is heartily at your service. JOHN LUDLOW.

University of Penna., Jan. 13, 1848.

From Prof. Giddings, Principal of Hartford Public High School.

PUBLIC HIGH SCHOOL, *Hartford, Jan.* 15, 1848.

GENTLEMEN,—An examination of the "Compendium of English Literature" so well satisfied me of its genuine merits, that I introduced it into a class of young ladies, in the High School, with despatch. I know not that I can do less than to commend it to the notice of teachers who are seeking for an appropriate book for the highest classes in advanced schools. Respectfully, &c., Yours,

Messrs. E. C. & J. Biddle. J. D. GIDDINGS.

From Prof. Goodrich, of Yale College.

I have read Professor Cleveland's "Compendium of English Literature" with lively interest. The selections are made with uncommon taste and judgment. The biographical notices and critical estimates prefixed to the extracts appear to me accurate and discriminating, and they certainly add much to the interest of the work, which supplies a want that has long been felt, and which must, I think, when known, be deemed an almost indispensable auxiliary in the highest classes of our schools and academies, in the study of English literature.

New Haven, January 20, 1848. CHAUNCEY A. GOODRICH.

From Prof. J. L. Kingsley, of Yale College.

New Haven, January 24, 1848.

DEAR SIR,—I received, a few weeks ago, through a bookseller in this town, a copy of your "Compendium of English Literature." From the examination I was able to make of it, it appeared to be a book much needed in our schools, and well adapted for the purpose intended. I have shown it to Miss D——, a teacher in one of our female schools, and she has adopted it as a text-book in one of her classes. I have no doubt that the work will meet with success.

Yours, respectfully, J L. KINGSLEY.

From Henry Reed, Esq., Professor of Belles Lettres, University of Pennsylvania.

Philadelphia, January 26, 1848.

GENTLEMEN,—I have delayed acknowledging the receipt of a copy of Professor Cleveland's "Compendium of English Literature," until I could make some examination of it. I am now glad to say to you, as the publishers, that I consider it entitled to decided recommendation. It is a well selected and comprehensive Compendium, and is, I think, excellently suited for its uses as "a text-book for schools and academies." The plan of the work appears to be in all respects judicious, and Mr. Cleveland has evidently taken much pains to give it great accuracy. Having a very extensive range for selection, he has chosen his materials well, and has skilfully introduced a great deal of valuable and interesting information respecting the course of English Literature. The work may also be used to illustrate the course of the English language, for in his selections from early authors, Mr. Cleveland has, with good judgment, made no attempt to modify or modernize the style. I need only add, that "the Compendium" is well calculated, in my opinion, both to promote and assist good teaching in a branch of education which stands somewhat in need of suitable text-books. Yours respectfully, HENRY REED.

Boston, March 7, 1848.

MY DEAR SIR,—I ought long ago to have acknowledged your very agreeable present of the Compendium of English Literature. It is just the thing I had been wishing to see, and I thank you for it.

I have examined the Compendium with great care, and have found it better suited than any other volume I have seen, to be a text-book in the study of the History of English Literature. In size it is of a right medium, not being of hopeless length, but yet long enough to make a deep impression, and to give a fair view of the writings of the more prominent of the English writers in prose and verse. The biographical notices are judicious, and the extracts are made with taste and discrimination, and present most attractive specimens of the treasures of our incomparable English language.

I have adopted it in my school, and have found it so useful and interesting that I hope it will obtain the circulation which it so richly deserves.

Respectfully yours, GEORGE B. EMERSON.

From the Rev. Dr. Aydelott, President of Woodward College.

Cincinnati, March 18, 1848.

DEAR SIR,—I have received and read with peculiar and very great satisfaction, your "Compendium of English Literature." *Peculiar*, because it realizes what I had long since sketched in my own mind, but had hardly dared to expect to see in existence. Very great satisfaction your book gave me, because it is prepared with so much literary taste and judgment, and evinces throughout so strict a regard for purity of morals.

While the character of your book is such as pre-eminently fits it for Colleges and High Schools, and the more advanced classes, both male and female, in all our Academical Institutions, it will be found very instructive to professional and literary gentlemen generally; and to that large, and I am happy to believe, increasing class of our business men who treasure up their leisure moments, and devote them to the cultivation of their intellect and taste.

That the sale of the "Compendium of English Literature" has already been so great, I am not at all surprised. As a text-book it will be universally adopted, and every man of an education above the most elementary, has felt the want of such a work, and must desire to possess it. Your friend and servant,

Prof. C. D. Cleveland. B. P. AYDELOTT.

From Rev. Charles B. Haddock, D. D., Professor of Intellectual Philosophy and English Literature in Dartmouth College.

MY DEAR SIR,—I have read your Compendium with great satisfaction and delight. It is a work much needed, and exceedingly well executed. The plan is, so far as I know, quite original; the biographical sketches are judicious and elegantly written; and the selection of authors, and of passages from their works, in an eminent degree fitted to introduce the student to the most finished and most wholesome portions of our Literature—the richest, noblest Literature the world has yet produced.

THE UNITED STATES ARITHMETIC.

THE UNITED STATES ARITHMETIC; designed for Academies and Schools. By William Vogdes, Professor of Mathematics in the Central High School of Philadelphia.

The first 104 pages of the above named work, embracing the rules to Compound Division inclusive, with 16 pages of miscellaneous exercises additional, are published as a *First Part*—designed for the use of Secondary Schools and the junior classes of Grammar Schools and Academies,—in a separate volume, at half the price of the whole work.

A *Key* to the above named work, designed for the use of Teachers, has also been published.

The United States Arithmetic has been adopted as a class book in the Public Schools of Philadelphia, Baltimore, Chicago, &c., and in very many highly respectable private seminaries throughout the Union.

Opinion of D. M. Reese, M. D., Superintendent of Common Schools for the City and County of New York.

New York, May 12, 1845.

DEAR SIR,—In the department of Arithmetic you are aware that the press has been prolific of late, and it has been to me quite a task to examine, and estimate as I could, the claims of each author in his laudable efforts to simplify the science, and construct a work on a hackneyed subject, which should, nevertheless, have novelty and merit.

Having now performed this labour, and compared all the different works upon the subject, in use in our Common Schools, and especially the recent publications and editions by Arithmeticians in various parts of our country, it is due to you that I should express my decided preference for your work over any other I have seen.

In divesting the science of much of its complexity and technicality, and especially in adapting the exercises to practical purposes and the actual business of life, you have, as I think, most happily succeeded. The questions and answers which precede the elementary rules, while they afford great facilities to an apt teacher, secure, on the part of the pupil, a full understanding of the technical terms and

signs, and the conditions of every operation. Your classification strikes me as well adapted to thorough instruction, and with your nomenclature I am equally pleased, rejecting, as you do, many of the modern innovations which detract from most of the books in use. The introduction of the chapter on "Arithmetical Symbols" is, in my judgment, timely and judicious; as also your retaining the rules of "Position," omitted in so many of the books, and yet so useful for the verification of complicated calculations. Under the head of "Exchange" you have fully embodied the legal aspects and bearings of the subject; while your Tables of "Foreign Moneys of Account," of the "Legal Value of Foreign Coins," and of the "Value of Foreign Moneys of Account, in computation at the Custom Houses of our country," are more complete and accurate than I have found in any other work. This latter remark applies also to your article on "Mensuration," including, as it does, the practical rules adapted to artificers' work. The examples in your book are more numerous than in any other work on the subject, and the price at which it is furnished to schools is so low that I cannot but regard this as among its merits, especially for our Common Schools, for which economy is of no inconsiderable importance.

These are some of the points I would name, as authorizing and constraining the opinion I have expressed, of your work; of the justice of which others can judge, as I have thus accompanied my testimonial with my reasons for approval.

I shall take great pleasure in bestowing, upon the United States Arithmetic, my unqualified commendation, and recommending its adoption and use in our Common Schools. With high respect, I remain your ob't serv't.,

D. MEREDITH REESE,
Super't. of Common Schools for the city and county of N. York

To Professor Vogdes.

Philadelphia High School, Feb. 18, 1845.

I have examined the Arithmetic of Prof. Vogdes with some care, and take great pleasure in bearing testimony to its merits. Its most obvious excellencies seem to be the following.—1. It is comprehensive, going fairly over the whole ground of common arithmetic, without being encumbered with unnecessary details. 2. It is practical, the rules being those in common use in stores and counting houses. 3. The sums are, for the most part, based upon actual facts, and not on mere fictitious transactions. 4. The rules are all followed with a neat and clear elucidation, which is of great advantage both to the instructor and the more advanced pupils. 5. Many curious and interesting facts in relation to the history of the science, are interspersed in the work, adding greatly to its value. 6. It is unusually rich in examples.

JOHN S. HART,
Principal of Philadelphia High School.

RING'S

3,000 EXERCISES IN ARITHMETIC.

THREE THOUSAND EXERCISES IN ARITHMETIC. By David Ring, Principal of the Female Public High School, Baltimore. Third edition, revised and corrected. With an Appendix, by W. J. Lewis.

It has been a frequent subject of complaint with intelligent teachers, that the Arithmetics in use—even those which are accounted the best—do not contain a sufficient number of exercises—of such especially, as have relation to the common business of life. To supply this deficiency, the above named work was prepared.

A *Key* to the exercises, for sale to Teachers only, has been published.

CRITTENDENS' DOUBLE ENTRY BOOK-KEEPING.

AN INDUCTIVE AND PRACTICAL SYSTEM OF DOUBLE ENTRY BOOK-KEEPING, on an entirely new Plan; having a general rule, deduced from the definition of Debtor and Creditor, applied to the Journalizing of all Transactions: containing Twelve Sets of Books for imparting a General Knowledge of the Science, with numerous and varied Entries, and illustrating Single and Partnership Business, both prosperous and adverse; also, Approved Forms of Auxiliary Books—A Set of Steamboat Books—A Vocabulary of Commercial Terms—Practical Forms for Keeping Books in different Branches of Business—Commercial Calculations—A

Table of Foreign Coins, and Moneys of Account, &c. Designed for the use of Private Students, Schools, and Practical Accountants. By A. F. & S. W. Crittenden, Accountants, of Philadelphia.

The above named work has been examined by, and received the approval of many of the best practical book-keepers in Boston, New York, Philadelphia, Baltimore, Richmond, Charleston, Savannah, Mobile, New Orleans, Natchez, Vicksburg, Memphis, St. Louis, Nashville, Louisville, Cincinnati, Wheeling, Pittsburg, Buffalo, &c.

That portion of the work especially adapted to impart to juvenile pupils a knowledge of the science of which it treats, is published as a SCHOOL EDITION.

The great favor with which these works have met in all the principal cities of the Union are the best evidence of their adaptation to the purposes for which designed—namely, to impart, with a moderate degree of application on the part of the learner, a *practical* knowledge of Book-Keeping.

Limited space will admit of the introduction here of but a few of the many testimonials to the merit of the school edition, received by the publishers, from teachers.

S. W. corner Twelfth and Filbert streets,

Philadelphia, October 24th, 1845.

We have examined Messrs. Crittendens' "School Edition of Double Entry Book-Keeping," and we are decidedly of opinion that it is entitled to be esteemed the clearest and most simple exposition of that useful science that has yet fallen under our notice—particularly in the establishment of general rules by a reasoning process, and its application in a manner suited to the commonest capacity, and calculated to ease the teacher of laborious and repeated explanations. We shall have pleasure in adopting it as our text book in communicating instruction upon this subject.

S. EDWARDS & J. PARTON.
J. SIMMONS, *Principal of Seminary, Locust above Eighth sts.*
J. F. BURNS, *Principal of Class'l Institute, George ab. Eleventh sts.*

I fully concur in the above opinion, and have introduced the work into my school.

W. M. RICE,
Principal of Classical School, Eighth and Cherry sts.

We are happy to add our testimonials in favor of Crittendens' work on Book-Keeping.

S. JONES,
Prin. of Class. and Math. Sem., 17 *So. Seventh st.*
J. WOOD, *Principal of Seminary, South Tenth st.*

I have examined the Double Entry Book-Keeping, School Edition, by the Messrs. Crittenden, and am so thoroughly convinced of its superiority to all others, that I have introduced it into the institution under my charge.

MILTON C. TRACY, *Principal of Mech. Inst. School, No.* 12 *Chambers st.*

New York, Nov. 17, 1845.

Troy, April 23, 1846.

We have examined Crittendens' system of Book-Keeping by Double Entry, School Edition, and are so fully convinced that it takes the precedence of all others, that we shall introduce it as a text book in the institutes under our charge.

R. S. HOWES, *Principal of Troy Academy.*
JOHN SMITH, A. M., *Teacher Select School.*
F. B. BURNETT, " " "
HORACE BACON, " " "
H. HAYWOOD, *Teacher Fourth Ward Public School.*

I have examined Crittendens' Double Entry Book Keeping, and from the numerous forms it presents, its frequent elucidations of the nature of Debit and Credit, the variety and practice it affords in the opening and closing of accounts, I give it a preference to any treatise I have previously seen on the subject.

HORACE MORRISON, *President of Baltimore College.*

Baltimore, January 2, 1846.

Pittsburg, July 29th, 1846.

We have carefully examined Crittendens' system of Book-Keeping by Double Entry, School Edition, and find it better adapted to the object intended than any other work of the kind that we have seen. We therefore cordially recomuend it to academies and schools throughout the country, and shall use our influence to secure its immediate introduction as a text book in the several institutions under our charge.

ISAAC WHITTIER, *Principal Third Ward Boys' School, Pittsburg.*
H. WILLIAMS, *Teacher of a Select School, Allegheny City.*
JOHN KELLY, *Teacher of First Ward High School, Allegheny City.*
R. J. CREIGHTON, *Teacher of Public School, Fourth Ward, Allegheny City.*

REV. N. TODD, *Principal Allegheny Seminary, Allegheny City.*
R. HAMERTON KELLY, *Ass't. Teacher Third Ward High School, Alleg. City.*
JAS. H. TEASDALE, *Principal Pittsburg Institute, Pittsburg.*
D. C. HOLMES, *Teacher of a Private School, Laceyville.*
D. H. TORREY, *Teacher of a Select School, Fifth and Market sts., Pittsburg.*
JOHN GRAY, " " " " *Fifth and Union sts.,* "
LEWIS BRADLEY, *Principal Allegheny Institute, Allegheny City.*
JORN STERRIT, *Teacher of a Public School, Second Ward, Allegheny City.*
C. WIDNEY, *Teacher of a Select School, Pittsburg.*

MESSRS. A. F. & S. W. CRITTENDEN.

State Military Academy, at the Citadel, Charleston, S. C.

Dear Sirs,—I have read and examined the method adopted in the treatises on Book-keeping by you, which you did me the kindness to leave at my room. I shall owe you many thanks for the labour of which your School Edition will relieve me. Its admirable exposition of the principles of Double Entry lays the whole science so completely before the student, that his instructor has nothing left him, beyond the examination of his work. The variety of forms, and the care taken to adapt them to different departments of business, is of *great* value—Indeed I do not hesitate to prefer it over any other treatise which has met my observation during the two years past, in which I have had the superintendence of this department in the Academy. Please send us twenty copies of the School Edition, and one of the larger size. Very respectfully your obedient servant,

F. W. CAPERS,
Prof. Nat. Phil. and Act'g. Supt. of State Military Acad.

MESSRS. A. F. & S. W. CRITTENDEN. *Cincinnati, Oct. 26th,* 1846.

Gentlemen:—After a satisfactory perusal of your "Inductive and Practical System of Double Entry Book-keeping," I consider it superior, in several respects, to any other work of the kind with which I am acquainted. The principles are clearly expressed; the rules are concise and accurate; the examples are progressively arranged, and admirably adapted to familiarize the mind with the manner of opening and closing books, and with the various kinds of business: the whole plan is well calculated to form good accountants—not proficient copyists. Though, for the better exercise of the pupil's judgment, I have hitherto excluded the use of all authors from the class under my tuition, an examination of your work has decided in favour of its adoption and future use as a text-book.

In addition to the facilities offered to the learner by your publication, I believe it will prove a valuable companion to the practical book-keeper. It will aid him in abridging his labour, and assist him when confused by novelty of transaction.

Respectfully yours, &c., J. J. QUINN,
St. Xavier College.

GUMMERE'S ASTRONOMY,

An Elementary Treatise on Astronomy; in two Parts: the first containing a clear and compendious view of the Theory; the second, a number of Practical Problems. To which are added, Solar, Lunar, and other Astronomical Tables. By John Gummere, A.M., Member of the Am. Philos. Soc., author of a Treatise on Surveying, &c. &c. Third edition, improved.

The work is used as a text book in the University of Pennsylvania, Union College, Wesleyan University, Rutger's College, United States Military Academy at West Point, Central High School of Philadelphia, Public High School of Baltimore, &c.

From Professor Olmstead, of Yale College.

We used your Astronomy last summer for a select class in practical astronomy, and liked it much. The present season those who would otherwise have taken this study, have chosen Fluxions.

Truly yours,
DENNISON OLMSTEAD.

John Gummere.

From Professor A. D. Bache, LL. D., Superintendent of U. S. Coast Survey.

The undersigned having used the second edition of Gummere's Astronomy as a text book in the University of Pennsylvania for several years, and the third

edition for a year when last connected with the University, has had a good opportunity to judge of its merits, and recommends it strongly for its clear style and perspicuous arrangement. The Appendix to the third edition contains matter of the highest interest to the practical astronomer as well as to the student.

A. D. BACHE,
Late Prof. of Natural Philosophy Univ. of Penna.

Messrs. E. C. & J. Biddle.

Extract from a letter to the Author.

November 28, 1843.

Respected Friend.—In returning to you my thanks for the copy of your work, I am happy in having it in my power to bear testimony to the favorable opinion which the late Dr. Bowditch entertained of the merits of the former editions. When I first engaged in astronomical computations some years ago, I applied to the Doctor for some direction as to the choice of suitable practical books. He was not without those European preferences so common to our scientific men, yet without hesitation he pronounced "Gummere's Astronomy" the best book obtainable for my purpose. Since then it has been one of my principal guide books, and one which I have always taken a pleasure in recommending to those wishing to become acquainted with the science, &c. Respectfully, your friend, JOHN DOWNES.

MAURY'S NAVIGATION.

The Text-Book of the U. S. Navy.

AN ELEMENTARY, PRACTICAL, AND THEORETICAL TREATISE ON NAVIGATION. By M. F. Maury, Lieut. U. S. Navy. Third Edition, much enlarged and improved.

GENERAL ORDER, NAVY DEPARTMENT.

Maury's Navigation is hereby adopted as the text-book of the Navy. Midshipmen are therefore required to make themselves acquainted with at least so much of Mathematics, Nautical Astronomy, and the other kindred branches of Navigation as is therein contained.

Professors of Mathematics and Boards for the examination of Midshipmen are charged with the execution of this order.

(Signed) J. Y. MASON.

The above named work has also been adopted as a text-book in the Central Public High School of Philadelphia, the Male High School of Baltimore, &c.

PEALE'S GRAPHICS.

GRAPHICS, THE ART OF ACCURATE DELINEATION. A System of School Exercise for the education of the eye, and the training of the hand, as auxiliary to Writing, Geography, and Drawing. In Five Books or Parts, with an Introduction for the use of Teachers, explanatory of the first Education of the Eye. By R. Peale, late Professor of Graphics in the High School of Philadelphia.

In use in Girard College, Philadelphia; the Public High Schools of Philadelphia and Baltimore; the Female Public Normal School of Philadelphia; Rutger's Female Institute, New York, &c.

HARDING'S ALPHABETICAL OUTLINES.

ALPHABETICAL OUTLINES IN GERMAN TEXT, OLD ENGLISH, PLAIN AND ORNAMENTAL PRINT, together with examples of Shading in each style; intended to facilitate improvement in this branch of Penmanship.

CONTROLLERS' COPY SLIPS.

These Copy Slips are of the old fashioned round style of writing, as opposed to the Carstairian or angular style; and consist of four sets, viz. Large Text hand, Text hand, Round hand, and Introduction to Running hand; each set containing 24 to 26 slips, or sentences, commencing with different letters of the alphabet. These sets or alphabets are stitched in book form, or pasted on separate slips of binder's board. In this latter form they are used in the Public Schools of Philadelphia where its economy has been satisfactorily tested.

DRAWING BOOK OF FLOWERS AND FRUIT.

DRAWING BOOK OF FLOWERS AND FRUIT; with beautifully coloured illustrations. Designed for the use of Schools, private pupils, and amateurs. By Mrs. Anne Hill.,

"A truly beautiful book. With the very attractive art, which it is designed to foster, we do not pretend to be particularly acquainted. We are sure that its moral tendencies are of the best description. A single glance is, however, all that is necessary to convince us that this volume will bear comparison with the productions of the same class that come to us from beyond the water. Two of our most distinguished artists, (Mr. Sully and Mr. Neagle,) speak of it in very favourable terms."—*Episcopal Recorder, Philada.*

"We have never seen anything of the kind, of American production, that could be at all compared to it, and cannot well imagine how the wealth and experience of Europe could produce a more excellent book of instruction, for the use of seminaries, private pupils, and amateurs. The designs and colouring appear faultless. The mechanical portions have been confided to master hands, and the very first artists in the country have warmly commended the whole work."—*Saturday Courier. Philada.*

Sir.—I have, according to your request, examined the "Drawing Book of Fruit and Flowers" which you have just published, designed by Mrs. Anne Hill.

It is a well executed work, and judiciously arranged to assist the student in his efforts to practise this beautiful department of the Fine Arts.

Respectfully, your obedient servant, THOS. SULLY.

Dear Sir.—I make the earliest possible acknowledgment of your kindness for the pleasure which you have afforded me over your new publication of a "Drawing Book of Fruit and Flowers" engraved and coloured from the delicate and masterly productions of Mrs. Anne Hill. This new work will be valuable in the hands of those who are learning the beautiful Art which the authoress so thoroughly understands and the principles and practice of which she is so capable of imparting to others, by means of written rules and pictorial illustrations, in outline, arrangement, colour and effect.

Hoping that your useful publication may be liberally patronized,

I am, dear sir, Your obliged humble servant,

JOHN NEAGLE.

PROGRESSIVE LESSONS IN THE PAINTING OF FLOWERS AND FRUIT.

BY MRS. ANNE HILL.

The series consists of six sheets, each containing four studies, beautifully coloured and gradually increasing in difficulty of execution. The price of the set is $1 50; of the numbers separately, Nos. 1 and 2 each 25 cents, Nos. 3 and 4 each 31¼ cents, and Nos. 5 and 6 each 37½ cents.

Opinions of the Press.

"The figures are truthfully designed and tastefully executed. We may safely commend them to those who would improve themselves in the art of drawing and painting flowers and fruit."—*U. States Gazette, Philada.*

"A fair friend of cultivated taste, whose opinion we have asked, authorizes us to pronounce these beautiful sheets the most admirably adapted to the use of pupils that she has ever seen."—*Banner of the Cross, Philada.*

OUTLINES OF SACRED HISTORY;

From the Creation of the World to the Destruction of Jerusalem. With Questions for Examination. Intended for the use of Schools and Families. New edition, enlarged and improved. Illustrated with 34 engravings on wood.

Published in London under the direction of the Committee of General Literature and Education, appointed by the Society for promoting Christian Knowledge.

From Rev. S. W. Crawford, A. M., Principal of Academical Department of University of Pennsylvania.

Dear Sir,—I have used the "Outlines of Sacred History" in the Academical Department of the University of Pennsylvania for several years, and am well pleased with it. Though an outline, it is sufficiently full for the purposes intended. The composition is good, and the leading facts succinctly though clearly stated. The chronological dates are a very important and useful part of the work. The poetical portions have been judiciously selected, and serve to give variety, interest, and animation to the work.

A faithful study of this book cannot fail to be attended with beneficial results to youth in families and schools.

Philadelphia, March 25th, 1843. S. W. CRAWFORD.

Extract from the last Annual Report of the late Superintendent of Common Schools of the city and county of New York—Col. Wm. L. Stone.

"But there are several other books wanted in those Schools (under the care of the Public School Society) among which is a good compend of Sacred History. * * * The officers of the district schools of the fourteenth ward, have adopted 'Outlines of Sacred History,'—an abridgment of great excellence."

TREGO'S GEOGRAPHY OF PENNSYLVANIA.

A GEOGRAPHY OF PENNSYLVANIA, containing an account of the History, Geographical Features, Soil, Climate, Geology, Botany, Zoology, Population, Education, Government, Finances, Productions, Trade, Rail Roads, Canals, &c., of the State; with a separate description of each County, and Questions for the convenience of Teachers. By Charles B. Trego, late Assistant State Geologist, &c., &c. Illustrated by a Map of the State and numerous engravings.

From the Hon. F. R. Shunk, late Superintendent of Common Schools of Pennsylvania, now, (1846,) Governor of the Commonwealth.

Pittsburgh, Dec. 19, 1843.

Dear Sir:—The Geography of Pennsylvania, by my friend Charles B. Trego, Esq., is an invaluable medium of spreading over the Commonwealth, apt knowledge of her immense resources and improvements, of the character of her people, and of her civil, religious, literary and charitable institutions.

Our citizens and our youth have been too long dependent upon our neighbours, for the Geography of our State. Mr. Trego has most happily made a Pennsylvania Book out of the description of Pennsylvania, and embodied in it that essential knowledge which children should be taught as soon as they are capable of loving the fatherland, and of apprehending its length and its breadth, its value and its resources, and all that varied information which must be acquired to form a correct estimate of the State and her inhabitants. and of her just claims to an elevated rank among her sister States.

The introduction of this invaluable book into our Common Schools, and other Seminaries of learning, will form an era in our history, from which we may date a more enlarged and generous attachment to our highly favoured Commonwealth. I am yours, respectfully, FRANCIS R. SHUNK.

JOHNSON'S MOFFAT'S NATURAL PHILOSOPHY.

A SYSTEM OF NATURAL PHILOSOPHY designed for the use of Schools and Academies, on the basis of Mr. J. M. Moffat, comprising Mechanics, Hydrostatics, Hydraulics, Pneumatics, Acoustics, Pyronomics,

Optics, Electricity, Galvanism and Magnetism: with Emendations, Notes Questions for Examination, &c. &c. By Prof. W. R. Johnson.

The title of the above work has been changed from "Scientific Class-Book, Part I."

—

JOHNSON'S MOFFAT'S CHEMISTRY.

AN ELEMENTARY TREATISE ON CHEMISTRY, together with Treatises on Metallurgy, Mineralogy, Crystallography, Geology, Oryctology, and Meteorology, designed for the use of Schools and Academies; on the basis of Mr. J. M. Moffat: with Additions, Emendations, Notes, References, Questions for Examination, &c. &c. By Prof. W. R. Johnson.

The title of the above work has been changed from "Scientific Class-Book, Part II."

☞ The Board of Controllers of the Public Schools of the First School District of Pennsylvania, (comprising the city and county of Philadelphia,) at a meeting held March 8, 1842, authorized the introduction into the Grammar Schools of the District of the above works, by Prof. Johnson.

OPINIONS OF PROFESSORS AND OTHER TEACHERS.

From Augustus W. Smith, A. M., Professor of Natural Philosophy and Mathematics. Wesleyan University, Middletown, Conn.

An examination of the "Scientific Class Book, Part I.," published by you, has left a very favourable impression. Of the excellencies of this work, there is one which establishes its claim to public favour, and will most certainly secure for it a speedy triumph over works of similar grade and pretensions. I allude to the introduction of many scientific facts, and principles which have hitherto been buried in the voluminous and inaccessible records of learned societies or are of too recent development to have been earlier embodied in any popular work. It appears to me to be one of the very few popular *scientific* works which are not dignified by their title, and one of the still smaller class which possess the merits of a public benefaction.

March 17, 1835. AUGUSTUS W. SMITH.

From Isaac Webb, Esq., A. M.

I fully concur in the opinion of the "Scientific Class-Book, Part I.," as expressed by Professor Smith. ISAAC WEBB.

From Alexander D. Bache, A. M., Professor of Natural Philosophy and Chemistry, University of Pennsylvania.

Sir,—I have examined, with much pleasure, the first part of the "Scientific Class-Book." The additions of the American editor appear to me to have well adapted the book for use in schools and academies. Its utility to the general reader, has, no doubt been increased by the same labours. Very respectfully yours,

September 16, 1835. A. D. BACHE.

From Rev. W. C. Fowler, A. M., C. A. S., Professor, Middlebury College, Vermont.

The "Scientific Class-Book" is admirably adapted to the use of high schools and academies, as an introduction to the principles of physical science. It is neither a meagre sketch on the one hand, nor on the other is it overloaded with facts. The principles are distinctly announced and the illustrations and proofs are interesting and satisfactory.

From Albert Hopkins, A. M., Professor of Mathematics and Natural Philosophy, Williams College.

A work like the "Scientific Class-Book," edited by Professor Johnson, has been for some time called for by an increasing taste for science, and a higher standard of popular education. Such works ought to meet the popular demand, and to elevate still higher the standard of attainment. Both these objects, I think, are adequately secured in the present work. I cheerfully recommend it.

Williamstown, Mass., February 22, 1836.

From Professor S. W. Budd, Jr., of Marshall College.

Marshall College, Mercersburg, Pa., January 1, 1845.

Dear Sirs,—Being pleased with Johnson's Moffat's Natural Philosophy, a copy of which I received some time since by your politeness, I named it to the Rector of the Preparatory Department of this Institution, who after more careful examination of the work, has introduced it as a text-book for the classes of Natural Philosophy in the School. Yours, very respectfully,

SAMUEL W. BUDD, JR.

From Rev. L. Van Bokkelen, Instructor in Natural Philosophy, St. Paul's College, Flushing, L. I.

The Scientific Class Book, edited by Prof. W. R. Johnson, has, for several years, been used as an elementary work in the grammar school of St. Paul's College; and it gives me great pleasure to state that it has proved well adapted to its purpose. The arrangement of chapters, the division into sections, the numerous diagrams, and the ample index, render it a most desirable book for teachers; while the many illustrations with which it abounds constantly remind the pupil of the practical value of the subject with which he is engaged. I have met with no work which I can more candidly recommend for use in our schools and academies.

L. VAN BOKKELEN.

FRENCH LESSONS FOR BEGINNERS.

L'ABEILLE POUR LES ENFANS, OU LEÇONS FRANÇAISES, 1ere Partie, a l'usage des ecoles.

Many compilations of short and interesting French tales have been offered to the public. In most of them, however, expressions are found which, although familiar to the ear of a Frenchman, offend that of a carefully educated American child. It is true that the French do not consider "Mon Dieu!" swearing; with them, it is equivalent to "Gracious!" or "Oh Dear!" but it is certainly desirable that the eye and the ear of the pupils of schools in this country should not become accustomed to such expressions. They have therefore been carefully excluded from this little work, as well as everything of an unchristian tendency. It is designed for the first reading book. The style is simple, the sentences short, and containing few idioms, inversions, or difficulties. At the end of each page is a translation of the idiomatic expressions it contains, and of the words used in an acceptation not given in the dictionary.

MANUAL OF CLASSICAL LITERATURE.

FOURTH EDITION, NINTH THOUSAND.

THE MANUAL OF CLASSICAL LITERATURE; From the German of J. J. Eschenburg, late Professor in the Carolinum, at Brunswick. With copious additions, by Professor N. W. Fiske, of Amherst College.

The work is divided into *five* PARTS, comprising *ten* distinct Treatises, viz:—on CLASSICAL GEOGRAPHY and TOPOGRAPHY; CLASSICAL CHRONOLOGY; GREEK and ROMAN MYTHOLOGY; GREEK ANTIQUITIES; ROMAN ANTIQUITIES; ARCHÆOLOGY OF ROMAN LITERATURE, (under this Archæology are noticed also Greek and Roman *Inscriptions, Coins, Medals, and Manuscripts;*) ARCHÆOLOGY OF ART, including *Sculpture, Gem Engraving, Painting and Architecture;* HISTORY OF GREEK LITERATURE; and HISTORY OF ROMAN LITERATURE—there being included in this History, *a general view of each department* of letters, together with individual *notices of the principal authors in the department*, and an account of the *editions*, *translations* and *works illustrative.* An Index of the Greek words, an Index of the Latin words, a Geographical Index, and a copious index of subjects, are included in the volume, which is also embellished by twenty finely executed copper-plate engravings, and by numerous wood cuts, together illustrating nearly five hundred different objects. In addition to the illustrations just named, *thirty-two finely executed copperplate engravings*, referred to in the MANUAL, are bound as a SUPPLEMENTAL VOLUME.

The vast amount of useful information that the *Manual* contains, presented in a *systematic form*, alike suitable for daily use, and convenient for reference, and the advantages it possesses over other works on the score of *economy*, from its embracing in one volume, that which in any other form must be sought for in several volumes, costing four or five times as much as this, recommend it to the notice of classical students and professional men.

It has been placed among the text-books in many of the Colleges of the United States, *e. g.*, Harvard, Wesleyan, and Miami Universities; Universities of Pennsylvania and Alabama; Rutger's, Amherst, Middlebury, Dartmouth, Bowdoin, Western Reserve, Marietta, Lafayette, Hamilton and Union Colleges, &c. &c.

OPINIONS.

Extract from a Letter to Professor Fiske, from Mr. Charles Beck, Professor of Latin in Harvard University.

"I cannot but express my admiration of the industry and care which are apparent to me in every part of the new edition, even after a very hasty comparison with the preceding editions. You have, indeed, a perfect right to consider yourself as the compiler and author of the work, rather than the translator; so many and important are the additions and improvements contributed by yourself or derived from other sources. The work is certainly the best and most complete of the kind in English; and in German, so rich in philological aids of every class, I know of none that surpasses this as to the quantity of matter, interesting and useful to the classical student, whether a learner or proficient."

From the Rev. Albert Barnes, Pastor of the First Presbyterian Church, Philadelphia, and author of Notes on the "Gospels," "Romans," "Hebrews," "Isaiah," &c.

Philadelphia, October 18, 1843.

Dear Sir,—I have been in possession of the first edition of Eschenburg's Manual of Classical Literature, by Prof. Fiske, for several years, and cheerfully and fully unite in the recommendations already furnished of the work, and which you have submitted to me. They are, indeed, recommendations of a high order; but, as far as I can judge, not beyond the merits of the book. I know nothing that can be compared with it; and it seems to me to be indispensable to one that would become familiar with the many important inquiries which occur to a student, respecting the geography, mythology, arts, literature and customs of the most interesting ancient nations of the world. I do not see how a professional man can well be without it; and I regard the translator as having rendered an essential service to the students in our academies and colleges, to the several learned professions, and to the cause of classical literature. The present edition is a great and decided improvement on the first. I am very respectfully yours, ALBERT BARNES.

FISKE'S CLASSICAL ANTIQUITIES.

This work which is designed for use in *High Schools and Academies*, comprises the *first three parts* of the "Manual of Classical Literature." It is an 8vo. volume of about 350 pages, and embraces five distinct treatises:—1. Classical Geography and Topography; 2. Classical Chronology; 3. Greek and Roman Mythology; 4. Greek Antiquities; 5. Roman Antiquities. With copper-plate and wood engravings, illustrating more than 300 different objects.

Its price is one half that of the "Manual."

SUNDAY SCHOOL TEACHER'S POLYGLOTT BIBLE.

In various styles of binding.

THE ENGLISH VERSION OF THE POLYGLOTT BIBLE, with marginal readings, and more than sixty thousand references to parallel and illustrative passages. Embellished with twelve fine Engravings, and eleven maps illustrative of different periods of Sacred History, all engraved on Steel, in the finest style of execution. 18mo. Ruby Type with a large face.

The publishers believe that this will be pronounced by all competent judges, to be the most beautiful pocket edition of the Bible, which has issued from the press, in this country.

ALSOP'S ALGEBRA.

AN ELEMENTARY TREATISE ON ALGEBRA, in which the principles of the science are familiarly explained and illustrated by numerous examples. Designed for the use of schools. By Samuel Alsop, Principal of Friends' Select School, Philadelphia.

Used as a text-book in Miami University, the Public High School of Philadelphia, &c.

A KEY, for the use of teachers, has been published by E. C. & J. B.

Report of the Philadelphia College of Teachers.

At a stated meeting of the Philadelphia College of Teachers, held on the 21st of October, 1846, the committee appointed to examine and report on An Elementary Treatise on Algebra, by Samuel Alsop, submitted the following Report, which was, on motion, adopted.

Although we have many elementary works on the subject of Algebra, we know of none which has issued from the American press, prior to the publication of this treatise, which contains the important discoveries which have been made within a few years in this department of mathematics. The ingenuity and learning of a few continental and English analysts, have resolved all the difficultics which attended the evolution of the roots of the higher equations; but so little attention have their labours received from American authors, that to a large portion of the public in this country they will first become known through the medium of Mr. Alsop's work.

The author, in his preface, states the object of his treatise to be "to present the science in a manner sufficiently simple to enable all to understand it, and yet so comprehensive as to embrace nearly everything that it is necessary for the student to learn." This, we believe, he has accomplished. His demonstrations are remarkable for clearness, brevity, and logical accuracy. Had they been otherwise, it would have been impossible to condense into 288 duodecimo pages the vast amount of information this work contains.

The subject is introduced by a few definitions and a number of examples of the easiest kind in Simple Equations. When the pupil commences the study with operations on letters, he is apt to comprehend neither the design nor the utility of the science. To obviate this objection, this preliminary chapter has been introduced. It also enables the author to bring in several subjects in the early part of the work which require a slight knowledge of equations, and which are placed, on this account, in most other treatises, near the close of the book. In the work before us, Proportion, Geometrical, Arithmetical and Harmonical Progression, Permutation and Combination, Involution, Evolution, Surds, and Imaginary Quantities, precede Simple Equations.

The limits we must necessarily assign to our notice, oblige us to confine our observations to those points in which this treatise differs most from those with which you are familiar. We invite your attention to the method of Synthetic Division, given on page 38. Of the amount of labour saved by this process, it is difficult to form an exaggerated estimate. For this beautiful contrivance, we are indebted to W. G. Horner, Esq., of Bath, England, whose researches in the higher branches of Algebra have placed him in the first rank among living analysts.

The Binomial Theorem, so far as relates to Integral Exponents, is demonstrated in a very simple and satisfactory manner, by means of the properties of Permutation and Combination.

Every experienced teacher knows that no one can become a thorough Algebraist until he has solved a great number of examples. It is not sufficient that he understands all the principles on which the solutions are founded; he must know when these principles are applicable, and how to apply them. Treatises on this science which contain only a few examples, and those of the simplest kind, are of little value as school books. This objection has no application to the work under review. Under all the rules, as far as Quadratic Equations, inclusive, will be found a copious collection of examples well calculated to tax the ingenuity of the pupil, and to familiarize him with the application of principles previously elucidated.

Contrary to the usual arrangement, the author has introduced a short section on Imaginary Quantities, immediately preceding Simple Equations. This enables the pupil to comprehend clearly the character of equations, and to evolve all the values of the unknown quantity.

The section on Pure Equations is unusually full, and is particularly worthy of commendation. Too little attention is generally devoted to this subject by Authors, Teachers, and Pupils. There is no department of Algebra more interesting, none which involves so many expedients and exercises so well the ingenuity of the pupil, and none which it is more important should be thoroughly understood. The author has solved ten questions, and the solutions include most of the methods pursued in the resolution of Pure Equations. The pupil should make himself well acquainted with these before he proceeds to the subsequent examples, some of which not a few teachers will consider rather too difficult for an elementary work. But it must be

remembered that it is only through examples of this description that the student can become initiated into the beautiful processes so much employed in Pure Equations. On this subject the author remarks, page 135: "The only difficulty in solving equations of this class, consists in reducing them so that the power may stand by itself. This being often difficult, we have appended a number of examples, the solution of which will bring before the student most of the methods employed in such cases. As he will probably require very frequent assistance from his teacher on first passing over the subject, he should be required to review his work until the methods have become thoroughly familiar. He will thus have acquired a knowledge of analysis which will be of great service, not only in pursuing the remainder of the work, but also in the study of the higher branches of pure mathematics."

The collection of Examples under Quadratic Equations is large, and they have been judiciously selected. In the solutions the pupil is required to obtain all the roots, positive and negative, real and imaginary. To him who designs to pursue his mathematical studies, the habit of doing this in all cases is particularly important, and it cannot be too early acquired.

The First Part of the work includes Quadratic Equations, and is for sale independent of the Second Part. It contains as much of the science as is generally taught in our common schools.

In chapter 7, the author enters fully into the doctrines of Equations. This portion is exceedingly interesting and valuable; and here the author's talent for condensation appears to the best advantage. The general properties of Equations, the number and character of the roots, the Transformation of Equations, and the removal of the 2d term, form the topics of the first two sections. Section 3 is devoted to the limits of the roots of Equations. Section 4 contains an exposition of Mr. Sturme's beautiful Theorem for the determination of the number and position of Imaginary Roots. We believe that this Theorem is not contained in any other treatise on Algebra which has been published in the United States. It is by far the most important discovery in this science which has been made in modern times; and, in connection with Mr. Horner's method of approximation, enables us, in every case, to determine all the roots of an equation.

The Numerical Solution of Equations forms the subject of the Eighth Chapter. Section 1st explains Cardan's Rule for the Solution of Cubic Equations; Section 2d illustrates Recurring Equations; and Sir Isaac Newton's Method of Divisors is discussed in the 3d Section. W. G. Horner's Method of Approximating to the Roots of Equations, and Binomial Equations, conclude this chapter.

The Ninth Chapter is devoted to the subject of Series, embracing the Method of Indeterminate Co-efficients, the Differential Method, and the Summation of Infinite Series. We are gratified to find that the first proposition (Art. 183) embraces the case where the exponents, as well as the co-efficients, are indeterminate. Those who may be desirous of seeing several new and important applications of this proposition in its extended form, are referred to Lewis's Trigonometry. By means of it, and of the first principles of the Differential Calculus, the Binomial Theorem, and the formulæ for the construction of Logarithms, Circular Arcs, Sines, Tangents, &c., are concisely demonstrated in that work.

The remaining thirty-six pages include Logarithms, Exponential Equations, Interest and Annuities, and Indeterminate and Diophantine Analysis. Although but little space is devoted to each of these topics, the articles in relation to them are very satisfactory, and embrace all the most important propositions.

Had a few pages been added to the volume illustrating the application of Algebra to the solution of Geometrical Problems, we think the usefulness of the work would have been somewhat increased. We cannot refer to any elementary treatise which contains a collection of suitable exercises of this description.

A few concluding remarks must close our notice. The treatise of Mr. Alsop will encounter objections from that numerous body who prefer school books the use of which involves little labor on the part of the teacher, and little intelligence on the part of the pupil. To those who are incapable of teaching, and to those who are incapable of learning works of a more elevated character, this treatise presents few attractions. But it is no new discovery that to become a master of the science of Algebra requires not only industry and application, but at least an ordinary share of natural ability. Then the question arises, whether our treatises shall be adapted to that class who are endowed with energy and talents which will enable them to become respectable mathematicians, or to that other class, who, possessing neither of these qualifications, can at best attain to little proficiency in the analytic art. Too many of our popular authors have directed their labors solely with reference to the wants of this latter class. Mr. Alsop has evidently had the former in view in the composition of his work, and to these we can confidently recommend it. They will find here more information on the subject of Algebra, and a greater variety of well-selected examples than are to be met with in any elementary treatise with which we are acquainted. (Signed) W. J. LEWIS,
WILLIAM VOGDES,
A. T. W. WRIGHT.

June 27, 1846.

I have carefully examined a Treatise on Algebra prepared by Samuel Alsop. The principles of the science are concisely but clearly explained, and the work is enriched by numerous and well-selected examples, admirably calculated to exercise the ingenuity of the pupil, and to engender a fondness for the study. More of the science of Algebra is contained in this work than is to be found in any other elementary treatise, European or American, with which I am acquainted. The chapters which relate to Pure Equations, and to Equations of the higher orders, particularly deserve commendation.

WILLIAM J. LEWIS,
Mathematical Teacher, Philadelphia.

E. C. & J. BIDDLE:— *Burlington, 7th mo. 18th,* 1846.

I have examined with some attention the new treatise on Algebra by Samuel Alsop, and I am greatly pleased with it: in my opinion the skill of a master of the subject, and the experience of a teacher have combined, in this performance, to produce a treatise better adapted to the purposes intended than any other of the numerous works now in common use.

Respectfully, &c.,
SAMUEL J. GUMMERE,
Prin. of Bdg. School for Boys.

From Benjamin Hallowell, late Principal of Alexandria Bdg. School.

Rockland, Md., 7 mo. 20th, 1846.

Respected Friends,—I have examined, with care, "An Elementary Treatise on Algebra, by Samuel Alsop," recently published by you, and I unhesitatingly express the opinion, that as a school book, for which it is designed, it is decidedly superior to any other treatise on the subject with which I am acquainted. It combines the practical character and judicious arrangement of Bonnycastle, with the simplicity of Bridge and Colburn, and the clear and concise illustrations and demonstrations of Day, Young and Bourdon.

A familiar acquaintance with the principles here developed, would form an excellent basis for an ordinary mathematical education, and an adequate preparation for the study of the higher analyses.

Your friend,
E. C. & J. BIDDLE. BENJAMIN HALLOWELL.

MESSRS. E. C. & J. BIDDLE, *Marshall College, Mercersburg, August* 26, 1846.

Gentlemen,—I have received from you, with much pleasure, the Treatise on Algebra by Mr. Alsop, the Principal of the Friends' School in Philadelphia. After a careful examination of the work, I find it all that might be expected from the experience and ability of Mr. Alsop, and fully justifying the excellent reputation of that school for sound instruction in the useful branches of learning. The work is full and comprehensive, and treats of several subjects which are often omitted in elementary works. I was pleased to notice the introduction of Sturm's theorem, and its use in the resolution of equations, which I have not seen done, excepting in the larger works of Mayer and Choquet, and Bourdon.

The printing and paper, and indeed the whole appearance of the book, reflect the greatest credit on your establishment.

With my best wishes for your efforts to effect improvements in our school books, I am, Gentlemen, your obedient servant,
SAMUEL W. BUDD, JR.,
Professor of Mathematics.

From Professor John Griscom, LL.D.

Burlington, N. J., 10th mo. 23d, 1846.

Having long been acquainted with the reputation of the author of this work as a very successful student of the higher mathematics, both of English and foreign authors, and a skilful and faithful teacher of youth, I have looked through his "Elementary Treatise on Algebra" with no little interest. The result of the examination is a full conviction that none of the treatises before extant, with which I have been acquainted through a long course of teaching, is so well adapted as this, under the care of an intelligent master, to indoctrinate the student into a thorough acquaintance with Algebraic Analysis, and qualify him for its application to Geometry and Physics.

The care manifested in the *gradation* of his treatise, the neatness of the solutions, and the numerous but choice selection of questions for practice, satisfactorily prove that the author is habituated to a knowledge of the wants of students, and has arranged his work in conformity to such experience.

JOHN GRISCOM.

Salem, Mass., Oct. 31, 1846.

"The Algebra, by Samuel Alsop, I consider one of the best which has ever been published. I hope it may have an extensive circulation."

JOSEPH WILLIAMS,
Principal of Phillips' School.

Wesleyan University, October 10th, 1846.

Some time during the last summer, I received a copy of Alsop's Algebra from the publishers. My engagements prevented me from examining the work at that time.

I have recently examined the arrangement, the mode of developing and establishing the principles, and the extent of the work; with each of which I am greatly pleased. While care seems to have been taken to simplify and adapt the introductory portion to the circumstances of beginners, the author has extended the work so as to embrace much elementary matter not usually introduced, and has presented it in a lucid and intelligible form. Any student who will make himself master of this work, may be assured that he will be prepared to advance to the higher branches of mathematics with ease and satisfaction. Indeed, it is well suited to make expert analysts. I consider it a work well adapted for the use of those schools in which classification according to capacity and degree of advancement may be made, and in which the time to be devoted to the study is not necessarily the same for all the pupils.

AUGUSTUS W. SMITH,
Prof. Mathematics and Astronomy.

VOGDES'S MENSURATION.

AN ELEMENTARY TREATISE ON MENSURATION AND PRACTICAL GEOMETRY; together with numerous Problems of practical importance in Mechanics. By William Vogdes, Professor of Mathematics in the Central High School of Philadelphia, author of the United States Arithmetic.

A KEY, for the use of teachers, has been published by E. C. & J. B.

Central High School, Philadelphia, Sept. 23d, 1846.

Gentlemen,—I have examined with some care the new work on Mensuration, by Prof. Vogdes. It seems to me eminently *practical*, as a work on that subject should be: it is unusually rich in the number and variety of *examples;* and altogether appears to be just such a text-book as was needed on that subject.

Very respectfully, JOHN S. HART,
Principal.

Messrs. E. C. & J. Biddle.

From Prof. John Griscom, LL.D.

Burlington, N. J., 9th mo. 30th, 1846.

The treatises on Mensuration, by Bonnycastle & Hutton, have been long in good repute in the schools of England and the United States. The work of Prof. Vogdes, while it professedly follows the course of instruction of these authors, appears to me to contain valuable emendations and additions, with the advantage of copious examples for exercising the skill of students. The problems in mechanics constitute an important appendage to the measurement of surfaces and solids. I know of no work I would sooner adopt as a school class-book on a study of so much practical value as Mensuration, than the treatise of Professor Vodges. The very neat style in which it appears, does great credit to the publishers.

JOHN GRISCOM.

Kensington, October 10, 1846.

Gentlemen,—The Treatise on Mensuration and Practical Geometry by Professor Vogdes, which you have recently published, seems to me to be the best elementary treatise on those subjects which has appeared. It contains all that is excellent in the works of Hutton, Hawney, Bonnycastle, Ostrander, and others, while in judicious arrangement, variety of illustration, and perfect adaptation to the wants of American scholars, it is far superior to any of them.

Every one who is desirous of acquiring a *practical* knowledge of that branch of Mathematics which ranks next to Arithmetic in usefulness, should obtain a copy of this truly practical work.

Very respectfully yours, JAMES M'CLURE.
Prin. of Master St. Pub. Grammar School.

Philadelphia, October 10, 1846.

The Treatise on Mensuration prepared by Professor Vogdes, is, in my opinion, better adapted to the wants of American pupils than any other work on this subject with which I am acquainted. The Mechanical Problems which form the latter part of the volume are appropriately introduced, and add considerably to its value.

WILLIAM J. LEWIS,
Mathematical Teacher, S. Fourth St.

Pennsylvania College, Oct. 29, 1846.

Dear Sir,—I have examined your Treatise on Mensuration, &c., and am fully persuaded of its excellence. The accuracy of its definitions, and the copiousness of its illustrations, make it admirably adapted to the wants of students in our elementary schools. Sincerely desiring that you may be compensated for your labor by its speedy introduction into our academies, &c., I remain truly yours,

M. L. STOEVER,

PROF. VOGDES. *Prin. of the Acad. Dept. Penna. College.*

Gentlemen,—A careful examination of "The Treatise on Mensuration and Practical Geometry by Professor Vogdes" has convinced me that it possesses many peculiar excellencies, among which the following appear to be the most obvious:—the rejection of such abstruse matter as would only tend to perplex and confuse the student; copious and varied illustration, and judicious arrangement; the omission of all except such practical matter as is requisite to the understanding of the subject; an entire suitableness to the wants of the student, and consequently a fulfilment of the profession set forth. It therefore cannot, in my opinion, be surpassed as an efficient and appropriate guide to both pupil and teacher.

Respectfully, NICHOLAS H. MAGUIRE,
Prin. of Coates St. Grammar School.

I fully concur in the opinion above expressed,

B. E. CHAMBERLIN,
Prin. of Buttonwood St. Grammar School.

Wilmington, Del., 11*th mo.* 2*d*, 1846.

Esteemed Friends,—I have examined with much satisfaction "An Elementary Treatise on Mensuration" by Professor Vogdes, lately published by you. The only work on the subject in use in our schools has been Bonnycastle's Mensuration—an excellent treatise, but deficient in several respects. Professor Vogdes has supplied most of those deficiencies,—he has simplified many of the rules, adapted others to the business of this country, and so extended the number of examples, as to afford full exercise on all the subjects treated of in the work.

I feel no hesitation in recommending it as a work well adapted to make the student familiar with the practical principles of Mensuration. I shall use it in my school. Respectfully, your friend,

SAMUEL ALSOP.

SANDFORD AND MERTON, IN FRENCH.

THE STORY OF SANDFORD AND MERTON, translated into French. By M. Berquin.

From Prof. F. A. Bregy, of the Public High School of Philadelphia.

Philadelphia, January 24, 1848.

GENTLEMEN,—No better idea could have been suggested to you than that of republishing this work of Berquin.

Among the French popular writers he occupies a place secondary to no one: the purity of his style is unsurpassed, and he has been properly called the *historian of young age*, which he pictures both as it is and should be.

The morality of all his works tends to awake the noblest and purest sentiments of the mind.

With my best wishes for the success of the work, should you publish it, I remain,

Yours, most respectfully, F. A. BREGY.

Messrs. E. C. & J. Biddle.

IN PRESS,

FIRST LESSONS IN ALGEBRA. By Samuel Alsop.

MISCELLANEOUS BOOKS

PUBLISHED BY E. C. & J. BIDDLE.

THE WORKS OF THOMAS DICK, LL.D.

ONLY COMPLETE EDITION.

The works of Thomas Dick, LL.D., illustrated by wood cuts representing more than 500 different objects, and embellished by a portrait of the author, from a fine engraving on steel; 10 vols. 12mo., muslin extra, or sheep binding.

The works embraced in this edition are as follows:—

Vol. 1.—THE PHILOSOPHY OF A FUTURE STATE.

Vol. 2.—THE CHRISTIAN PHILOSOPHER; or, The Connection of Science and Philosophy with Religion. From the eighth London edition; revised, corrected and greatly enlarged.

Vol. 3.—THE PHILOSOPHY OF RELIGION; or, An Illustration of the Moral Laws of the Universe.

Vol. 4.—ON THE IMPROVEMENT OF SOCIETY BY THE DIFFUSION OF KNOWLEDGE; or, An Illustration of the Advantages which would result from a more general Dissemination of Rational and Scientific Information among all ranks.

Vol. 5.—ON THE MENTAL ILLUMINATION AND MORAL IMPROVEMENT OF MANKIND; or, An Inquiry into the Means by which a General Diffusion of Knowledge and Moral Principle may be Promoted.

Vol. 6.—AN ESSAY ON THE SIN AND THE EVILS OF COVETOUSNESS, and the Happy Effects which would Flow from a Spirit of Christian Beneficence. Illustrated by a variety of facts, selected from sacred and civil history, and other documents.

Vol. 7.—CELESTIAL SCENERY; or, The Wonders of the Planetary System Displayed, Illustrating the Perfections of Deity and a Plurality of Worlds.

Vol. 8.—THE SIDEREAL HEAVENS, and other subjects connected with Astronomy, as Illustrative of the Character of the Deity and of an Infinity of Worlds.

Vol. 9.—THE PRACTICAL ASTRONOMER, comprising Illustrations of Light and Colors; practical descriptions of all kinds of Telescopes; the use of the Equatorial, Transit, Circular, and other Astronomical Instruments; a particular account of the Earl of Rosse's Large Telescopes, and other topics connected with Astronomy.

Vol. 10.—ON THE SOLAR SYSTEM; AND ON THE ATMOSPHERE AND ATMOSPHERICAL PHENOMENA.

The above volumes, containing about 3700 duodecimo pages of reading matter, have recently been published, with the same illustrations as above-named, and the 10 vols. bound in 5 vols., half muslin binding, are offered for sale *at the very reduced price of*

$3 25 PER COPY.

The vast fund of useful knowledge contained in the writings of Dr. Dick, together with the high-toned morality and religious feeling pervading them all, justly entitle them to a place in every School Library. For which purpose, the convenient size of the volumes, and the legible character of the type of this edition, render it peculiarly well fitted.

TAYLOR'S LIFE OF COWPER,

1 vol. 12mo.

LIFE OF WILLIAM COWPER, Esq., compiled from his Correspondence and other authentic sources of information; containing remarks on his writings, and on the peculiarities of his interesting character, never before published. By Thomas Taylor.

"A comprehensive and perspicuous memoir of Cowper has been much wanted, and will be read with gratification by the admirers of this amiable and pious man, whose accomplishments, excellencies, and peculiarity of character, have rendered him an object of interest to the world. We are indebted to Mr. Taylor for his excellent work, and for the happy manner in which it has been accomplished."—*Boston Traveller.*

MRS. SIGOURNEY'S SELECT POEMS.

SELECT POEMS; By Mrs. L. H. Sigourney. Fifth Edition. Embellished by seven fine Steel Engravings. This collection embraces the favourite Poems of the author. More than 10,000 copies of the volume have been sold.

"No poetess in our country has taken a purer flight through the realms of imagination than Mrs. Sigourney. There is a chaste dignity, a clear sweetness, a devotional delicacy pervading all her effusions. She instructs while she delights, and elevates while she refines. Every page breathes the life of poetry and the purity of religion. She pleases the aged and delights the young. The mourner may gather consolation from her musings; the thoughtless find themes for reflection, and the inexperienced may yield their imaginations and their hearts to her guidance, without fear of being betrayed into folly or misled into error."—*American Traveller, Boston.*

"The extraordinary and continued demand for the fervid and eloquent poetic writings of our American Hemans, is alike creditable to the public taste and the gifted pen that produced them. One never tires of scanning the simple, natural, yet elevated and expressive beauties of her undying numbers. Each succeeding edition appears in more elegant dress and ornament than the last; the fifth, now before us, being bound in richly embossed cloth, with gilt edges, &c. &c."—*Saturday Courier, Philada.*

LIBRARY OF ORATORY.

CHEAP EDITION.

THE LIBRARY OF ORATORY, the price of which, in sheep binding, has heretofore been $6 50 per copy, is now offered, in 4 vols. 8vo., half muslin binding, *at the very reduced price of*

$3 PER COPY.

This work, contains the most celebrated Speeches of eminent American, and other distinguished Orators below named.

Vol. 1. AMERICAN ORATORY; or Select Speeches of Eminent Americans. Compiled by a member of the Philadelphia Bar.

"The compiler of this volume has done himself credit in the performance of the labour which he assumed. He has, indeed, given us the speeches of our best orators, and he has not flattered a weak friend by connecting his name with the mighty ones of the land. There is no small gatherings—no piece *taken* because it would fill up a space—none *accepted* because it would gratify a few friends, and help an aspirant to public notice.

"The first speech is that of James Wilson, in the Convention of the Colony of Pennsylvania, 1775, in vindication of the Colonies. Then follow the speeches of Henry and of Randolph, in Virginia, on the expediency of adopting the Federal Constitution. Descending in point of time, we have the speeches of Fisher Ames, Governeur Morris, and James A. Bayard. Then we approach the stormy season of the 'Embargo and Non-importation,' and find John Randolph's celebrated speech, in which he made the first quotation from Campbell's song,

'Her march is on the mountain wave,
Her home is on the deep.'

Then follows the masterly effort of Josiah Quincy, goading the administration to a war, which nearly two years afterwards they declared. Calhoun, Gaston, William Pinckney and Webster are next heard—and these are succeeded by orations and discourses by Webster, Everett and Story.

"There is nothing small in this volume—the writer has selected diamonds from the heap, rich and brilliant, cutting as well as shining, and he has left treasures for those who would gather, not glean, after him."—*U. S. Gazette, Philada.*

Vol. 2. IRISH ELOQUENCE, comprising the speeches of the celebrated Irish Orators, Phillips, Curran, and Grattan; to which is added, the powerful appeal of Robert Emmet, at the close of his trial for high treason. Selected by a member of the Bar.

"The above work forms a complete and unique school of Irish oratory. To every member of the bar, to every clergyman, to every aspirant to political influence and admission into the legislative halls of his country, this practical text book of eloquence will be an honoured manual; and scarcely less does it recommend itself to every lover of literature, and each promoter of his country's good, who will be both rewarded for the purchase, the one by its high literary merits, and the other in the glowing picture it presents to him of personal sacrifices on the altar of public weal."—*Charleston Courier.*

Vol. 3. CELEBRATED SPEECHES of Chatham, Burke, and Erskine; to which is added the argument of Mr. Mackintosh in the case of Peltier. Selected by a member of the Bar.

"Much is gained in the richness and energy of expression, and the fertility of thought, by the frequent perusal of the masterpieces of rhetoric. Historical knowledge, too, is derived from them, vivified by the spirit of debate and indignant exposition of wrong. Some of the speeches in this acceptable collection relate to American affairs and character—we mean that of Burke on American Taxation, and those of Chatham which burst from his soul of fire. The selection is judicious, and the book indispensable for the library of every citizen who would be a public speaker."—*National Gazette, Philada.*

Vol. 4. SELECT SPEECHES of the Right Honourable William Huskisson, and of the Right Honourable William Windham. Edited by Robert Walsh, Esq., with a biographical and critical Introduction, by the editor.

"Few orators and statesmen of modern times have been more celebrated in their day and generation than Windham and Huskisson. For purity of style, dignity of sentiment, soundness and cogency of argument, and, above all, for political acumen and intelligence, there were none save Pitt and Fox who surpassed them. When the Right Hon. William Huskisson died, the last of the old parliamentary school may be said to have departed—of that school whose powerful orations found an echo in the most remote nations of the earth, and gave law both to savage and civilized man—whose eloquence arrested the victorious arms of France, and, by directing the thunder of the British arms, triumphed over every hostile people, save only one—and that one, America!

"The most magnificent specimens of their rhetoric are here published in a single volume, the contents of which have been very judiciously arranged by Robert Walsh, Esq., as editor. To him the public are indebted for two ably and beautifully written biographical sketches of the illustrious legislators, in which their characters are considered and developed in a truly impartial and philosophic spirit. The library of every public man may be said to be incomplete without this work, which affords an admirable study for students, as well of literature and law as of general polity."—*Penn. Inquirer, Philada.*

FOSTER'S ADDRESS TO THE YOUNG.

AN ADDRESS TO THE YOUNG, ON THE IMPORTANCE OF RELIGION. By John Foster, author of Essays on Decision of Character, &c.

"We are not going to hold a rush-light up to a book of John Foster's, but only mean to tell what is its intent. It is an awakening appeal to youth of the refined and educated sort, upon the subject of their personal religion. There can be no doubt as to its currency."—*The Presbyterian.*

WILBERFORCE'S PRACTICAL VIEW,

1 vol. 12mo.

A PRACTICAL VIEW OF THE PREVAILING RELIGIOUS SYSTEM OF PROFESSED CHRISTIANS IN THE HIGHER AND MIDDLE CLASSES, contrasted with Real Christianity. By William Wilberforce. With an Introductory Essay, by the Rev. Daniel Wilson, A. M., late Vicar of Islington, now Bishop of Calcutta.

THE BOOK OF HOMILIES,

1 vol. 8vo.

CERTAIN SERMONS OR HOMILIES appointed to be read in churches in the time of Queen Elizabeth: to which are added the Constitutions and Canons of the Church of England, set forth in the year 1603: with an Appendix, containing the Articles of Religion, Constitution and Canons of the Protestant Episcopal Church in the United States. Neatly bound in muslin. Price $2.

Jubilee College, Ill., Feb. 7, 1844.

SIR,—I am glad to hear you are about to publish the Homilies. Better late than never. Had they been in every Churchman's hand, and their blessed contents well treasured in his heart, his head would not be turning over his shoulder to Rome, with longing eyes for her abominations.

Go on then, my good sir, and get them before the public as soon as you can. You cannot do the Church a better service. My own clergy are all well supplied from the great numbers I brought with me from England.

With prayers for a divine blessing on your undertaking, I am your faithful friend and humble servant in the Lord Christ, PHILANDER CHASE,

Sen'r Bishop of the Prot. Epis. Church in the U. S. A.

PASTORAL LETTERS,

1 vol. 12mo.

THE PASTORAL LETTERS addressed by the House of Bishops of the Protestant Episcopal Church in the U. States, to the Clergy and members of said Church. The first of these letters, thirteen in number, was issued at the General Convention of 1808, and one other has been issued at each of the stated General Conventions since that period.

"It would not only be altogether superfluous, but highly presumptuous, to say a word by way of recommending a book like this, which comes to us clothed with such authority. We have here collected for the first time, in a very handsome volume, all the Pastoral Letters of our House of Bishops, from 1808 to 1844 inclusive—hitherto but little known, and accessible to only a very few among the clergy. The publishers have conferred an important benefit upon the Church by the republication, and we hope they will not go unrewarded."—*Banner of the Cross.*

"We welcome the appearance of these Letters in a neat volume. They contain a considerable amount of very intercsting matter; and make a valuable treatise upon Christian doctrine. Their highest value consists, however, in furnishing a concise and yet comprehensive view of the authoritative teaching of the Protestant Episcopal Church. They are the most mature, well-considered and deliberate expressions of opinion by the chief shepherds of our Zion—put forth under the sanction of the whole Church. Whatever authority the Church has, therefore, to teach and exhort, here is the highest expression of it, and the one to which the true Churchman is most bound to defer. Let the Church ponder well the godly instruction which these Letters contain. Their teachings are singularly adapted to the wants of these times. Who can fail to discern a special providence of God in the fact that the first thirteen Pastoral Letters should have been drawn by no other hands than those of White, Griswold and Chase; and that they should unitedly have been brought forward to speak to the Church at this particular time."—*Epis. Observer, Boston.*

THE FAMILY BOOK OF DEVOTION,

1 vol. 8vo.

THE FAMILY BOOK OF DEVOTION, containing Daily Morning and Evening Prayers for four weeks; a Sermon or Contemplation, and an Evening Prayer for every Sunday in the year; and an Appendix of Prayers for particular occasions. With an Introduction on the Importance of Family Religion, by the Rev. Herman Hooker, A. M.

BICKERSTETH'S HARMONY OF THE FOUR GOSPELS,

1 vol. 12mo.

A HARMONY OF THE FOUR GOSPELS. Founded on the arrangement of the Harmonia Evangelica, by the Rev. Edward Greswell. With the Practical Reflections of Dr. Doddridge. Designed for the use of families and schools, and for private edification. By the Rev. E. Bickersteth, Rector of Watton, Herts.

THE CHRISTIAN'S DEFENSIVE DICTIONARY,

1 vol. 12mo.

Being a refutation of the general objections to the Sacred Scriptures, arranged alphabetically. By the Rev. Dr. Sleigh.

THE CHRISTIAN LIBRARY,

2 vols. Imp. 8vo.

The above named publication offers at a *very low* price, to the Christian reader, a collection of works, many of which are not obtainable in any other form, in this country, and whose intrinsic value has been repeatedly attested by those well qualified to judge of their merits.

Among them (22 in number,) may be mentioned "Villers' Essay on the Spirit and Influence of the Reformation," "McCrie's History of the Progress and Suppression of the Reformation in Spain, in the 16th Century," "Smedley's History of the Reformed Religion in France," "Sismondi's History of the Crusades against the Albigenses, in the 13th Century," "Fairholme's Scripture Geology," "Gregory's Memoir of the Rev. Robert Hall," "Bridges' Memoir of Miss Mary Jane Graham," "Hone's Life of Bishop Wilson," "Bishop Butler's Sermons," "Rev. Robert Hall's Sermons," "Bishop Heber's Bampton Lectures, on the Personality and Office of the Christian Comforter," and "Rev. Dr. Tyng's Lectures on the Law and the Gospel."

FOX'S BOOK OF MARTYRS,

1 vol. 8vo.

A HISTORY OF THE LIVES, SUFFERINGS AND TRIUMPHANT DEATHS OF THE PRIMITIVE AS WELL AS THE PROTESTANT MARTYRS, from the commencement of Christianity to the latest periods of Pagan and Popish Persecution: to which is added an account of the Inquisition, the Bartholomew Massacre, the Massacre in France, and General Persecution under Louis XIV., the Massacres of the Irish Rebellion in the year 1641, and the Recent Persecutions of Protestants in the South of France. Originally composed by the Rev. John Fox, M. A. Embellished with 54 engravings on wood.

HISTORY OF PITCAIRN'S ISLAND,

1 Vol. 18mo.

ALECK; THE LAST OF THE MUTINEERS OF THE SHIP BOUNTY; OR THE HISTORY OF PITCAIRN'S ISLAND. Second edition.

A more complete or faithful account of the settlement on Pitcairn's Island will no where be found.

"We consider this as one of the best written books for the Sabbath School library, furnished by American authors,—and the facts it contains must interest all classes of readers."—*Mass. Sabbath School Treasury.*

"The narrative before us gives a complete account of the mutiny and settlement, and brings the history down to the latest intelligence received from the island. It is designed for the use of the young, who will find it almost as romantic, and quite as interesting as their favourite Robinson Crusoe; while readers of every age will peruse it with pleasure."—*Banner of the Cross, Philada.*

ROBINSON CRUSOE FOR THE YOUNG.

THE LIFE AND ADVENTURES OF ROBINSON CRUSOE. Revised with special reference to Moral Tendency, and adapted to the capacity of the Young, with numerous Illustrations.

"All the great adventures and 'hair-breadth 'scapes' of Robinson are here narrated in simple language, and delineated in beautifully engraved pictures, while the moral of each adventure is conveyed in an easy and natural manner to the youthful mind. The volume is got up in a very beautiful style in all respects, and will be generally sought as a suitable Christmas gift for children."—*Alexander's Weekly Messenger.*

"The work is embellished with nearly two hundred small and large engravings, most of them well executed; and will give great satisfaction to the juvenile portion of the community, if any aunt, elder sister, or friend who has an interest in that quarter, will persuade Kriss Kringle to drop it in their suspended stockings on Christmas morning."—*The Amer. Trav., Boston.*

"It is useless to speak of a book which *every body* knows; but the title page of the present new and beautiful edition shows that it has peculiar claims to confidence in selecting books for children. No present could be more acceptable to the young."—*Banner of the Cross, Phil.*

THE HOME BOOK OF HEALTH AND MEDICINE.

THE HOME BOOK OF HEALTH AND MEDICINE: a Popular Treatise on the means of avoiding and curing Diseases, and of preserving the Health and Vigour of the body to the latest period. Including an account of the nature and properties of Remedies, the Treatment of the Diseases of Women and Children, and the management of Pregnancy and Parturition. By a Physician of Philadelphia.

HOME BOOK OF HEALTH AND MEDICINE.

The author of this work (although his name does not appear on the title page) is well known to his professional brethren in Philadelphia as a man of great industry, excellent judgment, and extensive practical experience. These qualifications have been united in producing the "Home Book of Health and Medicine;" and as families resident in the country, and persons who make long voyages, require some aid in treating the emergencies of disease, we have much pleasure and confidence in recommending this work as the most judicious of its kind that has come under our notice. It embraces a brief but luminous view of the various branches of medical science, and may be read with advantage not only by those who have the responsible charge of invalids, but also by young men who are about commencing their medical studies, and who stand in need of a plain and comprehensive view of the healing art.

SAMUEL GEORGE MORTON, M. D.,
Professor of Anatomy in Pennsylvania College, Author of Illustrations of Pulmonary Consumption, &c. &c. &c.

I have examined the "Home Book of Medicine," and am of opinion that it is one of the best of its kind which has been published. To persons who are so situated as to be without the reach of judicious medical advice, the work will be found valuable.

THO. HARRIS, M. D.,
Surgeon U. S. Navy, Attending Surgeon Pennsylvania Hospital.

Princeton Theological Seminary Libraries
1 1012 01195 0476